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OBJECTIVE AND EXPERIMENTAL PSYCHIATRY

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OBJECTIVE AND EXPERIMENTAL PSYCHIATRY

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PREFACE TO SECOND EDITION

Since this book first appeared five years ago considerable advances have been made in the field of psychiatry. This is reflected in the fact that five more chapters have been added and that a radical rearrangement of the whole material has been necessary. Progress in the field of the oxidative functions, of electrical phenomena and of the effects of drugs upon behavior has been considerable. On the other hand it is apparent that difficulty in finding adequate working concepts has resulted in relatively less headway being made in the study of personality functions and of the function of thinking.

The most encouraging development of the last five years has been the gradual approximation of interest of the various social sciences. It is noteworthy that while the standard textbooks on psychiatry rarely refer to work outside the strict confines of their field, the publications of workers in the research field to an increasing extent draw upon the findings of those working in psychology, in sociology, in anthropology as well as the reports of those engaged in the biological sciences. This trend is reflected in the reorganization of the present edition of this book. Every effort has been made in considering the various functions of the organism to record the main factual material concerning all aspects of those functions, not simply such characteristics as are associated with abnormal behavior.

The division of human behavior into functional units cannot be considered as finally satisfactory. It is clearly a transitional step to a series of concepts concerning the integration of behavior of the organism and its interaction with the environment which we hope will be considerably more productive of new facts than past postulates have been. The measure of this dissatisfaction can be seen in the number of the recent hypotheses concerning behavior such as those put forward by the workers in the field of Gestalt psychology, in psychosomatics and psychobiology. We have made in this publication a tentative endeavor to seek further progress in the solution of this difficult problem by advocating as a working hypothesis the arrangement of the various functional activities of the organism in a scale in the order of their contribution to the speed of adaptation of the total organism.

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OBJECTIVE AND EXPERIMENTAL PSYCHIATRY

CHAPTER I

EXPERIMENTATION IN GENERAL

THE purpose of the first two chapters is to clarify the development and the present position of experimentation and quantitation in psychiatry. We propose also to criticize some of the assumptions upon which our present methods of fact gathering are based. It is our contention that these methods contain serious hidden errors which produce a constant and unrealized distortion of the natural facts.

We wish at this point to make a statement the truth of which is readily perceived as applied to ages other than our own, namely, that the general beliefs of an age tend to promote only those concepts which make for their own survival.

When animism held sway there was full and circumstantial evidence of the value of propitiation of the spirits of the trees and of the lakes. When witchcraft was a common belief, the first-hand accounts of the activities and attributes of witches recorded by individuals of otherwise sound and even outstanding judgment are such as almost to raise doubts of one's own scepticism. There is an evitable tendency for only those observations which are in accord with the current beliefs to survive; the others disappear. Thus it is necessary to take stock of the effects which our beliefs may actually be exercising upon our methods of fact gathering, and to examine the applicability of the experimental method to psychiatry, for, whatever may be its defects and limitations, it has the ineffable grace of being a self-correcting and self-criticizing method.

That the experimental and quantitative study of abnormal human behavior is a science in its early stages will be apparent from the fact that a great deal of its energy is still of necessity being directed to the evolution and perfection of experimental weapons, and that the connections between the various lines of investigation in many instances have not been established. The body of experimental and quantitative facts, though of growing importance and complexity, is not yet well synthesized.

Growth of Science. It may readily be demonstrated that a science passes through a series of developmental stages. There is an early phase, in which it is largely dependent on more or less dogmatic statements by its more gifted leaders. At this stage it is productive only in so far as the leaders are particularly capable men, for a natural attendant upon this dogmatism is respect for authority and unwillingness to see in the phenomena under study anything more than the concepts already evolved by the leaders. Moreover, the body of knowledge bears the heavy imprint of the personalities — the prejudices, beliefs, and blind spots — of its great men.

A later phase is the observational period during which a much larger body of workers in the science is brought into active critical work. At this stage the activity of the worker is no longer halted by constant references to authority, but can turn to a study of actual events in nature, which he can now view much more directly since he is not bound by the preconceived ideas which have been imposed upon his thinking. During this phase similarities and differences are sought, classifications are made, and to some extent the dynamics of the phenomena are sought out.

For the most part during this phase, chief interest is centered in identification of a phenomenon in relation to a body of already identified and classified phenomena, and attempts at its control are largely empirical, somewhat clumsy and superficial. The dynamics of the phenomena are grasped either intuitively or by observing the natural experiments which may by chance come under the observation of the worker.

Natural fortuitous experiments, helpful though they have proved themselves in the past, are at a disadvantage in that, since the variables cannot be controlled, they are not strictly comparable with one another, and can rarely be arranged to order. An essential aspect of the true experiment is that one should test one's theory of the dynamics of the experiment by comparing the actual result with the predicted result. In the natural experiment one follows a reverse procedure and theorizes about the dynamics from the results which one observes.

The progress at this stage, though much more assured than during the first, is still slow. This stage has the advantage over the first that correction of erroneous concepts is constantly going on by direct reference to the facts under study. However, in order to eliminate the variables in the natural experiments observed, enormous collections of observations are necessary. Through the necessity of waiting for these and for crucial and decisive situations to arise fortuitously, inadequately conceived theories are late in being corrected and the scientific effort is largely dissipated.

It should be borne in mind that observation may be carried out with varying degrees of accuracy. The observations of the untrained observer are notoriously inaccurate, while a considerably higher degree of accuracy is achieved when simple direct observations are supplemented by instruments of precision. The value of such instruments as the camera, microscope and telescope in increasing the range and accuracy of scientific observation is too well known to require further emphasis.

A further refinement of observation is achieved with the introduction of quantitation, in the form of statistical analysis of the findings. By its means general trends, variability and rhythms not immediately discernible by direct observation are brought out. Further it affords a valuable check upon subjectivism by counteracting the tendency of the observer to see what he expects or wants to see in the phenomena under observation. Where trained observation is combined with instrumentation and quantitation, results of very considerable objectivity and exactitude can be obtained. This is attested to by the reliability of the sciences of geology and astronomy, and is further borne out by the ability of the latter science to subject itself to the acid test of prediction.

Unfortunately, it cannot be claimed for psychiatry that the observational method has ever approached this degree of technical accuracy. A few workers are making use of statistical methods to analyze the results which they obtain by the observational method, but apart from their use in connection with experimental psychiatry, quantitation and instrumentation remain at an elementary level.

The third stage of development, and this represents the furthest point to which our science of fact finding has evolved, is the experimental, which seems in late years to be showing evidence of progressing in the direction of the emphasis of one of its aspects, namely quantitation. The basic sciences for some time have assumed more and more of a mathematical complexion and signs are not lacking that the biological sciences are to follow suit. This constitutes an exceedingly interesting and important development in that it suggests a basis upon which the artificially broken-up, separate "sciences" may be reunited. (The fundamental principle of the experimental method is the repetition under controlled circumstances of the reaction which is being studied and the verification of the hypothesis upon which the experiment is based by comparison of the result obtained with the predicted result. By manipulation of variables the causal relations of the phenomena of the reaction can be ascertained and steps can be taken toward controlling and directing the reaction.

It is occasionally leveled as a reproach against the experimental worker in the field of human behavior that what happens in the experimental environment may be totally different from what will occur in the uncontrolled environment of everyday life. Admittedly this is true, but he would be a very superficial thinker who did not realize that his experimental results do require translation into terms of everyday life. It is further to be realized that studies of isolated aspects of the human organism, even should they eventually involve every aspect of the different functions of the organism, will not give us complete information in regard to the functioning of the integrated organism. That this is now perceived is indicated by the existence of schools of thought such as those of Gestalt psychology and holism. Bearing these reservations in mind, namely, that our results will need translating and that the phenomena investigated during part activity require further consideration when studied in relation to the total activity of the organism, there is no reason why we should not pursue studies of part activities of the organisms and, indeed, strive to reduce those activities to their simplest functional terms. So long as we can state that we are studying "what it does," not "what it is," we can feel that we are engaged upon an investigation that is not foredoomed to sterility. Though there is evidence on every hand that we are in the process of passing from the observational to the experimental, our heritage even from the immediate past is largely an observational one. Upon it are based our classifications, our theories of dynamics, and our therapeutic procedures. It is clear that it will greatly assist the development of our experimental work if we can show where the observational methods have led us into error, or where, as we believe it possible to demonstrate, their use is inevitably associated with serious distortions of the recording of human behavior.

Observational Distortions. At this point it is well to look back at the developmental phase from which the science of abnormal human behavior is emerging. Data dealt with by the observational methods are subject to certain distortions. These arise from the very nature of the methods. It is most important that this tendency should be recognized and that concepts based on the use of these methods should be subjected to the closest scrutiny. Concepts, even when false, provided they blend with the fundamental beliefs of the times, retain a remarkable tenacity of life, and an equally remarkable capacity not only to inhibit progress in thinking within their region but also to produce secondary distortions in the form of premises deduced from them. This is well exemplified by the inhibiting influence exerted by Galen's concepts upon recognition of the mechanics of circulation.

It is important, therefore, to examine the distorting factors in the observational methods before passing on to a more intensive consideration of experimentation as a means of gaining control over events. Of these factors two are outstanding — conventionalization and projectionism.

Conventionalization. A major factor begins to operate as soon as we accept, in any unqualified way, the validity of observations made by the patient, his relatives, or by ourselves. This factor consists in our tendency to see in any series of happenings primarily what is expected, and to fail to see whatever does not fit in. Consequently, the various observers tend to see the events of a development of a patient's illness in terms of what they have already conceived the course to be. Indeed, up to a point, the more knowledge they have of the condition the more they will look for well-known symptoms and the more they will fail to see discordant events.

This factor operates still more strongly when information is sought, not from direct observation of the behavior of the individual, but from the recollections of the relatives or of the patient himself. Under such circumstances, even casual consideration should suffice to show how little agreement exists among a group of observers concerning the exact course taken by a series of past events. This lack of agreement becomes more severe the more distant the events under consideration.

Further errors frequently arise in our attempts to understand the nature of the forces making for the patient's recovery by questioning him, after he has finally recovered, as to the processes of readjustment as he noted them. In our experience it is only in a small percentage of cases that any agreement could be obtained between the patient's retrospective accounts and the verifiable incidents in his recovery. In the majority of cases the recollection was meager, the time relations were markedly distorted and, in many cases, actual amnesia existed. The same unclarity, or actual distortion, is to be found in the patient's account of the possible causal factors.

We should bear in mind that what the patient says regarding the development of his illness or his present status is and must remain of interest and value to us, but it should be studied as part of his behavior and not as affording a more or less disembodied report upon his past and present experience. Turning now to the statements of others concerning the development of the patient's reaction, we find that we are again on uncertain ground. That the statements of a group of individuals as to the exact sequence of events in an occurrence which they have all witnessed, differ remarkably is well known. When the emotions are aroused, as is the case among witnesses at a criminal prosecution, the divergence in testimony is markedly accentuated. It is superfluous to point out that the circumstances surrounding a mental upset are very emotional and are still only too often associated with ideas of right and wrong, the patient's abnormal reaction provoking in some of the observers the belief that this reaction is something that the patient can stop or at least could have prevented. In addition, there is the still quite profound stigma felt not only by the patient, but also by the relatives. Work in the field of memory indicates that the distortions which occur in the recollection of dreams also occur in the recollection of experiences taking place in waking life, especially when the experience is emotionally colored.

While we all realize the force of the truism that the past affects the present, we fail to bring into our calculations what we also know quite well to be true, namely, that while the present obviously cannot alter events which have occurred in the past, it can and constantly does alter our conception of them. That it does, is given tacit recognition in a number of everyday phrases such as "I can see things very differently now," and "it has dawned upon me since." It is also implicit in the statements of some persons that they do not know how they came to act as they did in certain situations, and even perhaps in the apparent attempt on the part of a certain proportion of people recovering from mental disturbances to disclaim their past behavior by saying that it all seems like a dream, that they would not have been ill if others had not put them in a mental hospital, or that they have no recollection at all of their behavior while in the psychotic state. One is justified in suggesting that these people are viewing their past behavior in the light of the present; and, though at the time it had their sanction, they can, in consequence of the different point of view which they are afforded by the present, no longer understand it, and that the psychotic must distort or actually repudiate it.

A further objection to the observations of those untrained observers, our informants — and this also applies to a large extent to the worker, even though he is a trained observer — is that they do not observe and record in a purely mechanical way. There is a considerable difference between the way in which the human observer records and reproduces and the way in which, for example, a camera records. This is true even when the reproduction is called for at the earliest possible moment. The reason for this is that the organism does not record passively, but enters into its observation. The observation is not a mere record of events but a conception to which the observer brings many of his own predilections and prejudices. The observation and its subsequent reproduction may be profoundly affected by a number of incidents such as what the observer has conjectured will be the course of events, the attention which he bestows upon the phenomena, and the fatigue or efficiency which he displays at the time.

A final objection is based upon the fact, well known to us since Ebbinghaus' experiments upon the memory, that the more the material we are remembering conforms to already familiar concepts, the better we remember. Consequently we find that in a chain of circumstances those events which conform to the concept that the observer already has, tend to be remembered and reproduced in his account of the development of the patient's disorder, while those that do not are forgotten. This tends to promote the conventionalization of the reaction types.

Projectionism. By projectionism is meant the attempt to ascribe to the patient the feelings and thinking which we consider from our experience he should be entertaining on being exposed to a given situation.

The capacity to project is based upon the capacity to place ourselves in the other man's position by allowing his behavior to produce in us an echo of the condition of the other organism, or more precisely of the condition of the other man's consciousness. By thus referring to our own feelings and thinking we believe that we can obtain an understanding of the other man's condition. One might describe it as a hetero-introspection. This contention is based upon two assumptions, both of which are open to devastating criticism. The first assumption is that the patient's behavior — and under this we include not only what he says but also what he does — conveys direct information concerning what he is experiencing. What the patient does, and more particularly what he says, are to be regarded as symbols, in so far as they represent what is going on in the organism as a whole. These symbols are capable of conveying only generalities as to the general tenor of the mood and, to a degree decreasing with the intelligence of the individual, a picture of his point of view. They are not susceptible to the fine analysis which further progress in psychiatry demands. The accurate analysis of what these symbols actually mean to the individual displaying them would demand that the observer should have an experience identical with his. When this is not the case, the observer utilizing them is doing so in a conventionalized manner, and not necessarily with an appreciation of what they meant to the subject.

The second assumption is that what is happening in consciousness affords us an adequate picture of the behavior of the organism as a whole or even of the higher functions.

It is not within the scope of this work, and indeed, owing to lack of factual data, it is impossible, to reduce the functions of consciousness to a series of generalizations. It must suffice if we can obtain some general indications as to whether we are justified in working further with the idea that consciousness is a dispassionate recorder of the vicissitudes of the organism or of mentation itself, and whether we are justified in assuming that the events occurring in consciousness report more truly than any other sets of events the entire activity of the organism.

There is already an abundance of material to show that consciousness does not report all the changes which occur at the level of mentation taken in the wide sense, or that it makes its report in a direct form.

No statement which leads us to a further understanding of the phenomenon is given us by consciousness in its report of the operation of inhibition, as demonstrated objectively by

Pavlov. The very fact that this important aspect of mentation, and the nature of the conditioned reflex, were first worked out on animals whose consciousness is not accessible to us must demonstrate that the study of consciousness is not the only route through which the study of mentation can be carried out.

Indeed in Pavlov's work we find corroboration of our contention that study of conscious mental activity carried out by projectionistic methods may be actually a hindrance, for he relates that it was only after he and his co-workers resolved to be guided only by the objective behavior of the animals under experiment and not by conjectures as to their state of consciousness that progress was actually made.

The work of the Freudian school constitutes one of the most extensive bodies of evidence to demonstrate that the factors provoking abnormal psychobiological upset, while acting at the level of mentation, nevertheless may not extend into consciousness. What reports consciousness has to make of these factors is so disguised and altered that it offers little or no direct clue to the forces operating to produce abnormal reactions.

As further evidence of the fact that consciousness does not report on all activities at the level of mentation, one could point out that the psychogalvanic reflex is capable of demonstrating that certain words are of affective importance to the subject when the subject's own introspection fails to find that these words are of more importance than usual.

Much of the work of the experimental psychologist deals with aspects of mentation regarding which little or no information can be obtained from a study of consciousness. How little we should know of perseveration, how little of our exact knowledge of intelligence or of work curves we should now possess, if we had limited ourselves to a study of consciousness! Finally, to draw evidence from mental hospital experience, how little have our retrospective accounts of the conscious experiences of stupors assisted us in elucidating these conditions.

From these remarks it is evident that though we are not yet in a position to state clearly what the functions of consciousness are, we can state quite definitely what they are not. Consciousness does not furnish us with a report on many of the aspects of mentation which may well occupy an important place in the causation of the abnormal reactions with which we have to deal. Moreover, in many cases when the report actually is furnished by consciousness, that report has undergone so much amendment and adaptation in the process of rising into consciousness that it fails to provide us with adequate information on the really active issue. Hence our reliance upon the patient's introspection and upon the projectionism of ourselves and his friends is quite unwarranted and misleading.

The function of projection is one which seduces the worker with peculiar ease, and indeed a considerable prestige still attaches to the individual who is specially gifted in this direction. It is of considerable consolation to the patient to find that he is in touch with someone who, with the help of comparatively little explanation, is able to understand what he thinks and feels about the things that have been happening to him at the level of consciousness. I do not think that one can be justly accused of exaggeration if one declares that an individual passing through a depressive reaction is as much benefited by the ministrations of a projectionistic intuitive psychiatrist as a dead Chinaman is benefited by the presence of a professional mourner. For example, the present-day case records of depressive patients almost exclusively are records of variations and fluctuations in psychic pain. Our present approach to this reaction is quite comparable to what would obtain if we concentrated our attention solely upon the location, nature and fluctuations of the somatic pain in appendicitis. And indeed in the past there have been counterparts to this limitation of the interest as represented by the attention which was given by Greek medicine to the pulse and by medieval medicine to the inspection of the urine as indicating the condition of the individual.

While the influence of projectionism is seen most clearly in our approach to the study of the mood disorders, it can be seen also in our approach to other types of abnormal reaction, save when the cause of such reaction is seen to lie quite definitely at the lower levels. When such is the case little or no interest is directed toward the study of events at the level of mentation.

There is much evidence to show that in our attempts at projectionism we are frequently completely deceived as to what the patient actually experiences. The response in consciousness to a bereavement is by convention accepted as being one of sorrow. Actual investigation shows that the response may vary from acute grief to hearty rejoicing. While we may err considerably in endeavoring to estimate the patient's past conscious reaction to a situation, we are no less likely to err in estimating what the patient is experiencing at the moment. We are all familiar with the fact that patients may pass from a depressive phase in which acute sorrow is being experienced into one in which the external exhibitions of their sorrow remain practically unaltered, although this expression has now deteriorated into a formula having little connection with what is actually felt. We have even evolved a test by means of pictures of enacted grief, joy, anger, and fear, to estimate the ability of the individual to judge emotional reactions. In so far as the pictures represent mere characterization by an actor who at the moment is certainly not feeling what he is enacting, this offers rather a devastating comment upon the value of our projectionistic methods.

However, even if we do succeed in forming a general estimate of what the subject is experiencing by means of projectionism, we shall be devoting our attention to a series of phenomena which have only the most remote and involved relationship to what is happening to the organism as a whole.

With the exception of a few schools of thought, among them being those who apparently regard the individual as simply a structural-physiological organism, the main effort in psychiatry is devoted to a projectionistic study of consciousness, and our case records are to an overwhelming degree studies merely of the vicissitudes of consciousness. There appears little logical limit to the projectionistic study of the individual, a fact to which the ever-growing unwieldy mass of case records bears eloquent witness.

On the false premise that consciousness represents a short cut to the study of mentation we have erected an etiological system, the authenticity of which is, to say the least, doubtful. As has been shown our projectionistic methods have naturally focused our interests almost entirely upon psychic pain as an etiological factor.

Hence, in standard psychiatric textbooks we find few reaction types, save where the causal factor obviously lies at the lower functional levels, in which "mental stress or strain, worry, anxiety, tension or conflict" are not cited as the etiological factors. While it might be possible, on the grounds of differences in the predisposing factors, such as the individual's constitution, to explain why it is that the same precipitating etiological factors produce such different reaction types, this difficulty becomes almost insurmountable when we consider that the same etiological factors are cited as producing different reactions in the same individual at different times in his life, as in depressions and excitements.

Thus far, our methods have not enabled us to set up experimental situations which would permit of the testing out of concepts reached by the method of observational procedures, and consequently we have had to take advantage of what large scale, crude experiments have occurred spontaneously.

It is of interest to note that during the first World War period when bereavements, separations, financial loss, fear and conflict involved large numbers of people and involved them to a greater degree than ever before, no increase in the number of persons admitted to mental hospitals was to be observed. The experiences in financial depressions have been similar.

Moreover, careful scrutiny of the lives of the persons who have broken down apparently in consequence of the psychic pain provoked by one of the projectionistic etiological factors will often show that there have been other periods in their lives in which they have suffered as much pain as, or more pain than, during the period when this breakdown occurred.

Experimental Method. The introduction of the experimental method constitutes a considerable advance over observational procedures. The fact that experimentation consists predominantly in the setting up of a preliminary hypothesis, the working out of the hypothesis in a controlled situation, followed by comparison of the results obtained with those predicted results, eliminates to a large extent the distortions peculiar to the observational procedures. This elimination is carried still further by the fact that experimentation is for the most part concerned with immediate situations. Moreover, experimental work, before being accepted as valid, must be capable of being repeated under the same circumstances in the hands of others, and premises based on these experimentally obtained concepts, granted that they are logically derived and are susceptible of experimentation, must in turn, when worked out experimentally, contribute to the validity of the original concepts. This procedure, with its closely correlated series of checks and counterchecks, clearly acts to reduce considerably those distortions which arise from conventionalization and projectionism.

The utilization of experimental methods, however, encounters and creates certain serious difficulties of its own which require detailed consideration. Recent study of scientific methodology has made it increasingly clear that a profound difference exists between the concepts used to express the data of physics and those employed to formulate the data of behavior. The former readily permit of the application of experimental methods and of prediction without the necessity of assembling all the antecedent data concerning the phenomenon under scrutiny. The series of concepts which we use to describe human behavior still call in large measure for a knowledge of all the antecedent happenings. So long as this remains true it is clearly impossible that precise prediction can be obtained. It is necessary, therefore, to face the inevitability of working out concepts which can deal with the organism as a complete phenomenon at any given moment and not as a continuing upgrowth from the past. Both viewpoints are true, though neither is exclusively so. It is clear that the organism does react in terms of the environmental or "field" forces acting upon it at the moment and by virtue of its nature at that time. It is also true that it has attained its nature by virtue of the experiences through which it has passed. Nevertheless, though neither of these conceptual bases is exclusively true, our growing acquaintance with the laws of neogenesis has shown that it is perfectly possible to make headway with the assistance of postulates which include only part of the truth, *e.g.*, our hypothesis regarding ether and atomic structure, so long as we recognize the limits of these postulates. It is quite possible, moreover, that the greater utilization of the time factor in the formation of concepts based upon the idea of the organism as explicable only in terms of its past will permit of their being more readily handled.

In the meantime, increasing attention is being paid to the fact that much of our data cannot yet be subjected to experimental procedures. For example, the meanings which things have for the individual can rarely be investigated directly by experimental methods. Usually it is necessary to resort to the investigation of the participation of lower functional levels in the individual's reaction to the things in question. Thus, in estimating the meaning which an unpleasant situation has for an individual, recourse has been had to the investigation of the effects upon the brain wave pattern, upon the skin resistance and the skin temperature. While such procedures enable us to clarify, in the absence of the cooperation of the individual, the very important issue of whether or not a given situation is of special significance and even in rough terms its degree of significance, they afford only limited information as to the total meaning which a thing has for the individual.

In medicine in general, the same difficulty has been encountered, though in lesser degree. Solution has, however, been more satisfactorily found in the use of part-indices. The febrile reaction, for example, consists among other symptoms in a feeling of shivering, tiredness in the legs, throbbing in the ears, slight hyperesthesia, tachycardia, and increased heat production. The reaction as a whole cannot be adequately subjected to experimental procedure, but variations in heat production can be readily measured and therefore treated experimentally. In consequence of this and in consequence of the fact that this aspect of the febrile reaction correlated highly with the various other aspects of the reaction and with the reaction as a whole, considerable success has been obtained by the use of increased heat production as a part-index of the febrile reaction.

At present considerable work is being done on the problem of developing similar part-indices in connection with behavioral reactions. While, as mentioned earlier, those already defined afford rather limited information, theoretically there is every reason to hope that part-indices may be worked out which will be more highly correlated with the total reaction and which will at the same time be susceptible to treatment by experimental methods.

At the same time, under the influence of Gestalt psychology a considerable amount of work is being devoted to the devising of techniques which permit the handling of the behavior of the individual as a whole rather than as represented by part functions. This line of attack, as well as that described under the search for part-indices, is calling for a considerable amount of recasting of the data of psychiatry into different conceptual forms. There is little doubt that the nature of the concepts in which our data are now organized stands to a very considerable extent in the way of the development of experimental methods. If, for example, it were possible logically to restate the facts of the manic depressive reaction in terms of excitation and inhibition, it would be possible to handle them much more easily than is possible at present.

A major factor which needs to be stressed consists in the essential variability of human behavior. On the one hand, practically all experimental methods have thus far been united in demanding that as a prerequisite for their successful application all variables should be under control. On the other hand, it is precisely the higher functions which show the greatest variability since they constitute the means whereby adaptation of the organism to its internal and external environment is carried on most actively. The speed of adaptation at the higher levels is so great that the behavior of the organism may be modified even by a single experience.

Attempts are being made to meet this difficulty in various ways. Techniques are being developed which permit of the continuous collection of data, rather than the collecting of occasional samples. This constitutes in some measure a return to the principles of the work curves which furnished a good deal of necessary ground material at a time when psychology and psychiatry were just entering the industrial field. Our present use of these principles is, however, considerably facilitated by an immense advance in accuracy and range of instrumentation which has taken place in the interval. A further fact which differentiates our present and former utilization of these principles is that in the time which has elapsed since they were first utilized, the work of the Gestalt psychologists has provided us with a series of data concerning the relation of part to total functioning, which considerably influences the manner in which experimental situations for continuous recordings are now set up.

Further, with the assistance of the statisticians, activity is being directed toward the study of variability as a phenomenon in itself. Increasing evidence is accumulating which tends to indicate that in some instances individuals may be more adequately differentiated not by the average level of a particular function, but by the degree of variation around their average which they may show. Similarly, in the field of abnormal behavior it is now being regularly reported that variation in level of function rather than abnormality of average level constitutes in many instances the differentiating function between abnormal and control groups. In this connection there seems to be little doubt that many "normal" standards — blood sugar, pulse, basal metabolism — will have to be reinvestigated from the point of view of variability. Long term investigations of a few individuals rather than single observation on a large number of subjects is a further indication of the appreciation of the problems posed by variability.

Finally, experimental methods as well as those which rely exclusively upon observation have to contend with difficulties which arise from the fact that the worker is also part of the experiment. As was indicated earlier in this chapter, experimental procedures suffer less from this fact than do other methods. Nevertheless, the type of problem which is selected in the first instance and the decision as to which of later appearing leads seems most desirable to follow up depends upon the worker. He makes these decisions on the basis of his own desires and hopes, his beliefs and his experiential background in general. Consequently there is on the part even of those who work in the experimental field an impetus to advance knowledge in the direction of what is already known. As yet no blueprints covering the systematic working out of a phenomenon have been drawn up. Indeed, the idea that such is necessary has barely emerged. Nevertheless, it is a healthy sign that it is now recognized that not only the worker's technical or intellectual capacities but also his attributes as a member of a culture and perhaps the very nature of his structure as a human organism are of importance in the matter of advancing knowledge; and it is still more promising evidence of intellectual growth that we begin to realize that those aspects of a phenomenon which we customarily investigate and endeavor to control constitute only a fraction of the total attributes.

CHAPTER II

NATURE OF THE ORGANISM

MANY of the sciences concerned with the reactions of the human organism have made considerable progress without finding themselves under the necessity of defining, with any degree of explicitness, their concepts of the nature of the organism. They have been affected to some degree by hypotheses introduced from other fields; for example, both anatomy and physiology have benefited greatly from the comparative studies of other forms of organism which were set up under the stimulation of the Darwinian theories concerning evolution.

Until relatively recent times those working with the human organism carried over into their working concepts a certain duality of thought which was and still is present in daily life. In so far as they were scientists and impressed by the astonishing advances achieved by physics and chemistry they were strict determinists, and their investigations were based on the inevitability with which a given stimulus must elicit a given reaction.

In so far, however, as they were dominated by the current religious beliefs or, while denying specific religious dogmas were influenced by those great cultural dogmas which, acting as corollaries of these beliefs, pervaded the thinking of the times, they saw the individual as exercising choice between patterns of behavior on the basis of a system of moral concepts designated as good or bad and inherited from an earlier time and a totally different setting. The growth of a systematic series of concepts dealing with the causation of behavior was rendered even more difficult, since the confusion occasioned by the spectacle of each human organism acting with ideal volitional freedom was rendered worse confounded by the widespread, though logically irreconcilable, belief that a beneficent providence or an ever present evil might unpredictably interfere at any given moment in the scene.

Under these circumstances the scientist found himself forced to work and live on a basis of "as if." He continued his studies of respiratory exchanges as if the laws of cause and effect were inviolable and as a social being he continued to deal with the behavior of his fellow men as if they were ideally free agents. The progress of scientific achievement in the nineteenth century demonstrates that this curious duality of concept proved workable enough within limitations.

We have now reached the point where we stand before these limitations and seek to pass them. Specifically, we now find ourselves under the necessity of studying the reactions of the whole organism. To achieve this a fresh series of concepts concerning the nature of the organism and its reactions to the environment is necessary.

The concepts, which are at present evolving, tend to demonstrate the organism as a considerably more integral part of its surroundings than was formerly the case. They stress the fact that the organism is essentially a specialized part of its environment, that the materials which compose it are without exception those which are found at large around it, and that consequently in some respects the organism may reasonably be expected to react to forces in a way similar to that shown by the less specialized environment. At the same time it is realized that many of the reactions of the new organism are considerably influenced by the organisms from which it originally arose. As can be readily perceived we are a long way from attaining a simple series of concepts to embrace the nature of the organism and its relationship to the environment or even from defining which series of concepts it is most expedient to use in a given situation. On the one hand we see the undeniable unity of the organism with its environment; on the other we see that the organism is clearly a highly specialized part of the environment and possesses functions which are not found elsewhere. We see that the organism is probably influenced in its reactions by the kind of organism from which it originates and also that its reactions may be distinctly modified by interaction with the environment. Furthermore, we can grasp the extraordinary variability of reaction shown by a group of organisms and also the fact that in many respects there is an astonishing similarity of reaction — the range of pulse rate, the fear mechanism and the span of memory may be regarded as revealing great variability and remarkable stability from community to community and from generation to generation depending upon one's point of view.

There is no question that the attempt to study wholes has constituted a most valuable reaction from the urge to study ever smaller aspects of behavior which, drawing its inspiration from the physical sciences, came to dominate the investigation of human behavior during the nineteenth century. Both behaviorism and Gestalt psychology represent a revolt against the sterility to which the extreme application of this psychology of fragments of behavior led. But the movement is a revolt and has all the characteristic tendencies to move over into a position which, though diametrically opposed, may be equally extreme. It is most important to maintain that habitually coordinated activities or functions exist within the human organism which have as good claim to be studied as wholes as does the whole represented by the organism itself. It is true that these functions are by no means self-contained wholes. They are extremely dependent upon the setting in which they operate, but similarly the organism itself is not an independent source of activity. It, too, is dependent upon its setting. Our guide in determining the aspects of behavior with which we may profitably work must remain pragmatic. If it serves to advance our control over human behavior we may reasonably assume that what we have studied possesses a degree of functional unity; if it does not, it may be that we are in danger of working with non-integrated fragments.

Turning to a more detailed consideration of the nature of the individual, we find the tacit acceptance by the majority of workers of the concept of an organism which possesses a series of functions. It is considered that these functions are established in the form of a hierarchy. The higher functions exercise, it is believed, a dominating influence over the lower, but at the same time a considerable interaction exists, so that if there are serious disturbances at the lower functional levels these may result in considerable alteration of the higher functions, or even in their temporary obliteration. On the other hand, the higher functions are viewed as capable of producing disturbances in the lower functions and also to some extent as subsuming and symbolizing lower functional activities. The function of language may be considered to represent a symbolization of massive and crude activities expressed through the lower level functions in earlier stages of development of the individual and of the species. This tendency to express through the earlier lower functional levels still exists, as can be demonstrated by muscular tensions during articulation, by the persistent tendency to gesticulate and by the extent to which acutely increasing fear or rage will inhibit the function of language and promote communication through the earlier simpler functions of gesture, expression and inarticulate sounds.

Adaptational Scale. Little or no attempt has been made to place these various functions in a meaningful relation to each other, and attempts to explain the interaction of various functions, especially the interactions which exist between higher and lower functional levels, have been unsuccessful.

It is suggested that considerable value would be gained from any concept which would permit of placing the various functions in an orderly and meaningful relationship to each other. In this connection we may point to the concept of the electromagnetic spectrum. This has permitted the placing of such apparently diverse things as the color red, x-rays, heat and the Hertzian waves in a relationship to each other on the basis of wave length.

The atomic table provides a further example of the great value of the development of a concept which permits the placing of otherwise very different things in an orderly relationship to each other.

It is proposed here that the various functions or activities of the organisms can also be placed in a scale. The basis suggested is the extent to which they promote adaptability. The higher functions, for example those activities which we subsume under the term memory, are conspicuous for the speed with which they facilitate adaptation. Frequently it is necessary that the organism be exposed to a given situation only once for it to react differently, *i.e.*, to show adaptation. On the other hand, adaptation of the cardiovascular function is considerably slower. I do not here refer to the immediate response to an extra load, as in climbing stairs, for after the immediate stimulus has gone the cardiovascular function returns to its former capacity. Reference is had, rather, to the slow adaptation which is relatively stable, and which goes on during a period of training. The cardiovascular system returns to its former functional level after much training only if it is clear that the adaptation which it has undergone is no longer necessary.

Arranging the various functions of the organism in such a scale, one finds that those aspects of behavior which we have been accustomed to describe as higher level activities — learning, remembering, desensitizing and conditioning — appear at the upper level of the scale by reason of the greater readiness with which they promote adaptation. Next in series come those mid-level functions which are usually studied by the physiologist and biochemist — assimilation, gaseous exchange, elimination and the defensive mechanisms such as leukocytosis and immunity development, which are found at this level. All those activities can readily be shown to undergo adaptation, but with them the adaptation is slower. Still lower in the scale come functions the reactivity of which is so slow that we frequently fail to see them as functions at all. If, however, we define as function an activity of the organism which enables it to deal with some particular aspect of the environment and by adapting either the organism to the environment or vice versa enables the organism to survive, it will readily be seen that such things as the shape of the organism, the rigidity afforded by the bony skeleton and the texture of the skin are to be seen as functions of the organism. Changes at this level, as contrasted with those occurring at the level at which memory is placed, take place extremely slowly, yet it is a matter of experience that changes in shape do take place as in adaptation to occupation and to accidental mutilation.

Finally, there are those functions which react so slowly that adaptation does not occur within the life of one individual but requires several generations.

With regard to the lowest level reactions it is necessary to emphasize that, from the data at present available, it seems improbable that changes produced in an individual are handed down to his descendants. In other words, the theory that acquired characteristics are inherited is still unproved. Although, for this reason, it cannot be demonstrated that certain functions adapt so slowly that in a given stock it requires several generations to produce changes, nevertheless it can be readily shown that in the case of the species as a whole natural selection does result in the modification of functions that do not show adaptation within the period of a single life span.

At the present time data are so scanty concerning the actual speed of adaptation shown by these various functions that their location on the adaptational scale can be stated only in approximate terms. Further and more precise study should be of value in two major fields. First, by study of the speed of adaptation it should be possible to separate more clearly functions which are somewhat poorly differentiated, for example, memory, learning and conditioning. Secondly, precise location of the various functions in the adaptational scale should permit of a better concept of the relationship between the various functions, and also possibly gaps in the scale might provide leads for the detection of functions which are at first unrecognized or confusedly incorporated in other concepts.

It seems desirable, however, again to accent the fact that in talking of functions we do not have in mind in any sense disarticulated systems, but that in referring to the functions of learning and memory, for example, we are referring to the learning organism and the remembering organism. It is most important to stress this for the clear reason that the manner in which these activities are carried out will be certainly affected by the general state of the organism at the time.

Functional Interaction. Discussion of the series of functions and emphasis upon the unitary action of the organism naturally raises the question of the manner in which the activities of the various functions are interrelated. Specifically one may point to the problem of how the oxygen consumption of the cerebral cells affects the function of memory. The amount of experimental material upon this point, as well as upon the whole extremely important question of functional interaction, is scanty. In the specific situation mentioned it can readily be demonstrated that fluctuations of oxygen consumption below a certain minimal level will result in fluctuations in the memorizing capacity of the organism, but little or nothing is known concerning the actual mechanism.

Certain tentative concepts have been evolved largely for experimental purposes. The first is that the lower functions must be maintained within a limited range in order to permit the normal activities of the higher functions. Undoubtedly many of the behavior disorders associated with uremia, dehydration, anoxemia or hypoglycemia are, to a large extent, to be ascribed to the profoundly disturbed homeostasis, rather than to be specially associated with the particular kind of disturbance.

From investigations into the effects of anoxemia upon behavior it is also becoming clear that the speed with which changes are produced in the lower functional levels has a bearing upon the amount of disturbance at the higher functional levels. The more rapidly they are produced, the more serious the disturbance.

A third concept which is generally employed, though as yet with relatively little experimental confirmation, is that disturbances originating in the higher functional levels but involving lower functions may, if they persist, produce irreversible changes at the lower levels. For example, Lewis (1925) suggested that long continued emotional strain might produce persistent hyperthyroidism. The material available will be dealt with more specifically later, in connection with the interrelation of definite functions.

Interorganismal Relations. A series of concepts concerning the relationship between organisms is now in existence. Of these concepts, one of the most promising is that which considers the individual as not entirely psychologically separate from others around him. It can be readily seen that many of the functions of the individual can have meaning only if it is understood that he will function in a group. This applies particularly to those functions which subserve communicating.

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Speech, gesture and expression clearly are meaningless activities unless other organisms are present to react to them. Similarly, the sexual functions, including such activities as breast feeding, are also dependent upon a group existence (Angyal, 1938). In view of this, it is of importance to see the individual as not entirely separated from those around him — as belonging to the compositae rather than to the cruciferae. This field is still relatively unexplored, though an excellent beginning has been made by the study of group activities of children (Gesell, 1930), and the investigation of the effects of group function upon work output (Whitehead, 1935).

Organism-Environmental Relations. The fundamental concept upon which rests all investigation of the relations between organism and environment consists in the statement that a given environmental stimulus will produce a given reaction by the organism. It is generally conceded that in such a highly adaptive organism as the human subject it is exceedingly difficult to duplicate with complete precision the circumstances of any given experimental situation and thus to demonstrate that the relationship between cause and effect is as clearly operative at the higher functional levels as it is in the field of physics. Mechanism, however, is the dominant trend in scientific thinking; concepts based upon this viewpoint have been outstandingly successful in dealing with the lower functional levels and, moreover, the more exactly we can duplicate any given experimental situation even in regard to the higher functional levels the more closely do we afford a verification of the cause and effect hypothesis. In consequence of these facts we are forced to continue to work with the hypothesis though already some doubts are beginning to appear.

Causation. The whole question of cause and effect relative to control of human behavior would seem to be worth rethinking. It is clear that by analogy from some of the abnormal reactions in the field of general medicine, particularly the microbic infections, the best control of abnormal behavior may be offered by acting upon the primary cause, namely the pathogenic organism. In other fields of medicine this is not necessarily the case. For example, when an individual sustains a burn by an electrical current we do not concern ourselves with the latter — to do so would be like anointing the dagger which had inflicted the wound — but we concern ourselves with the injury inflicted, a phenomenon which occupies second place in the chain of cause and effect. It requires little imagination to see that we meet many cases in general medicine in which we do not have to concern ourselves with the first link in the chain but with one which may have little connection with the original one.

In the study of abnormal human behavior we can see that many of the problems which are ultimately brought before us for solution may have a connection with the original circumstances which provoked them simply because they are members of the same chain of cause and effect. However, the nature of the originally provoking circumstances may be of no importance so far as controlling the course of events and of effect, at the stage at which the problem is brought to us.

Thus we see that the fact that the account of the circumstances of the origination of the train of abnormal events may well be incorrect through subjectivism, poor observation and retrospective falsification need not concern us gravely, at least in dealing with the immediate problem. We can obtain from the patient at the moment of our observation information regarding his present status. What has occurred to him in the past does not matter save in so far as it has been incorporated in a significant manner into his present organization.

The work which is being done in the field of functional autonomy supports this point of view. It has been shown that in the case of rats in which cleaning activities had been increased by painting the ears with collodion on several successive days, the animals continued to show much more cleaning activity than the control animals for a considerable period after the application had stopped and all evidence of irritation of the area had disappeared (Olson, 1929). It is also reported that, when incentives are effective and the work output is speeded up, an increased output continues even after the incentives have been withdrawn (Allport, 1937).

It is interesting to note, moreover, that experimental work from other fields is beginning to raise problems which are difficult to fit into the current concepts of cause and effect. The work of Child (1924) and of Coghill (1929) upon the correlation of the development of behavior and the development of neural mechanisms has been referred to (Dunbar, 1938) as indicating the possibility that the organism may be capable of spontaneous activity, *i.e.*, activity not dependent upon environmental stimuli. Both workers have shown that, in the case of certain lower forms of life, activity of an organized nature may appear before connection between the sensory and motor components of their neural mechanism has been effected. Those working in the field of human behavior have, however, always recognized the fact that certain action tendencies are innate in the organism and that they will affect the reaction of the particular organism to a situation. It does not appear that the work of Child and Coghill goes beyond this concept or that it invalidates the postulate that a given organism, the potentialities of which are known, will react in a given way to a given stimulus.

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CHAPTER III

THE LEARNING FUNCTION

PRECISE definition of the activities carried out by the learning organism cannot be made. We have pointed out earlier that the term function cannot be considered in the sense of the older faculty but is to be thought of rather as a central tendency the borders of which pass over insensibly into the field of other related functions. This viewpoint is substantiated by the numerous investigations which have been made of the learning organism and which have shown that there is a definite degree of correlation between the estimates of the capacity of the learning function in a given individual and, for example, his memory function.

A statement of the relationship of the learning function to certain analogous activities is, however, possible in general terms. The two functions, the relationship of which it is particularly desirable to clarify, are those of memory and conditioning. With regard to the first it may be said that if one thinks of memory in terms of registration, retention and recall, learning may reasonably be said to coincide with the first (Cason, 1937). The matter of whether what is learned is retained and subsequently utilized, *i.e.*, produces adaptational modifications in the behavior of the organism, is one which falls more completely within the field of the memory function.

Conditioning may be considered as an aspect of learning which is specially concerned with the production in the organism of adaptational changes to objects and situations to which it has been hitherto indifferent, but which have acquired meaning for the organism by reason of a temporal relationship to objects and situations which already possess significance for that organism. Much of the activity carried on under conditioning does not appear in consciousness. The adaptational process takes place rather more slowly as a rule than through the function of learning or memory; moreover, its adaptational effects more often manifest themselves through the mid-functional levels. For these reasons it is possible to place conditioning rather lower in the adaptational scale.

Measurement of Learning Function. The growth of our information concerning the learning function and the development of experimental procedures for its investigation constitute one of the most notable advances in the field of human behavior. The procedures evolved by psychiatry for work in this field differ from those used by the psychologist. The latter, being primarily interested in such things as the speed of learning, transfer of learning and the conditions under which learning is expedited or retarded, makes use of tests designed essentially to provide information upon these points. The psychiatrist, however, governed by the necessity of providing a working solution for patients whose learning function he is investigating, requires data not only upon the capacity to learn, but upon what the patient has learned. Hence the value to the psychiatrist of the intelligence tests as opposed to more strictly learning tests.

Though this difference in approach exists, the correlation between learning and intelligence tests is high. Moreover, the correlation becomes higher if numerous learning tests are carried out on the same individual and the composite score is used for purposes of comparison. The correlation becomes still higher the more complex the test becomes. In the latter case the coefficients may reach + 0.80 (Boring, Lungfeld, Weld, 1935).

For these reasons we have incorporated learning and intelligence under one heading. It seems highly probable that the majority of these activities which the psychologist groups as learning and by far the greater number of those things which the psychiatrist considers as intelligence are identical. To a considerable extent any apparent difference derives from the methods which the psychologist and psychiatrist use in order to study them. In particular we feel that the intelligence tests of the psychiatrist impart a spurious sense of the static to a function which is preeminently adaptive in its activity.

In utilizing the intelligence tests it is necessary, however, to understand fully their limits and for this reason it is essential to grasp the fundamental principles upon which these testing techniques have been developed.

Those most frequently employed are simply compilations of short questions which the consensus of informed opinion considers that intelligent persons should be able to answer (Thorndike, 1924), and should be able to answer the better and in the greater number the more intelligent the persons are. It is important to realize that the arbiter remains the consensus of common sense; we have as yet no truly objective or absolute measure of the capacity to learn.

The established tests in current usage are well standardized, but caution must be exercised regarding the reliability of the less well known. Various figures have been suggested as to the number of subjects desirable for accurate standardization. Fifty subjects at each age level have been advocated by Bronner, Healy, Lowe, and Shimberg (1937). In the recent revision of the Stanford-Binet tests by Terman and Merrill (1937), while the number used to effect standardization is much greater — the authors mention the necessity of analyzing more than six thousand records — it is clear that the intensive investigations of the learning process which have been carried out, particularly since the introduction of the original Binet-

Simon tests, have resulted in marked advances in our knowledge of the structure of intelligence tests. The effects of the cultural milieu as influenced by family economics or racial extraction must be taken into account in selecting an adequate sample of the population for the purposes of standardization. Moreover, there is now an increasing tendency to rely upon statistical devices such as the degree of correlation which a particular test item shows with the total as a means of selecting the more informative tests. It is to be pointed out, moreover, that tests are not only to be standardized as to values but also as to methods of administration (Wells, 1927).

With the development of our knowledge concerning the learning function it has become apparent that the test instruments, such as have been just described, while still the most efficient, may be too narrowly based. The capacity of the learning function is now recognized more clearly as expressing itself not only in the ability to verbalize adequately or to perform tasks in response to request. It expresses itself much more widely — in motor skills, in adaptive behavior and in interorganismal relations.

Advantage is taken of this fact in the study of the learning function in lower animals. In work with the human organism this wider viewpoint concerning the learning function has found expression in the study of pre-school children (Gesell, 1930, 1937). The work is being gradually extended to higher age groups and it is reasonable to hope that this more comprehensive approach will enable us to achieve a closer correlation between our estimate of the learning function and actual life performance, as distinct from school and college performance, than the present intelligence tests permit.

Earlier work by the psychiatrist in the field of intelligence was hampered by attempts to work out a single test item which would permit estimation of the whole range of juvenile and adult intelligence. The success of the tests introduced by

Binet and Simon (1905) rests largely upon the recognition of the fact that in the devising of a reliable test procedure numerous test items were necessary. A similar point of view was advanced almost simultaneously by Spearman (1904), in his theory of factors. To explain the operation of intelligence he (1927) advanced the suggestion that the latter is the product of two factors — *g*, which denotes the inherent intelligence of the individual, and *s*, the special ability through which his intelligence is being manifested at the time. For example, *g* in a person who had special ability in mathematics but had a limited capacity to form analogies would be rated very differently depending on whether the test employed was comprised of the forming of analogies or the solving of mathematical problems. It is clear that a much truer picture of his actual intelligence will be gained if both forms of test are used and it is also obvious that the more tests we can use practically, the more the influence of specially good endowment or specially poor endowment in any one field will tend to cancel themselves out and we will thus obtain a closer and closer approximation to *g*, his inherent ability.

One further provision, however, must be made, namely, that there must be no undue overlapping of the tests. To cite an extreme example, in testing our mathematician we must not confine our scale to a series in algebra, in arithmetic, in geometry and in maze-solving, for there is a close correlation between abilities in these fields, and consequently the special ability of our mathematician in this direction would cause his intelligence to be rated too high.

Validity of Intelligence Tests. Stress is laid upon the fact that we do not know what we are actually testing under the name of intelligence (Spearman, 1927), that our only acquaintance with the phenomena of intelligence is indirect, and that intelligence scores, once obtained, are directly comparable only to a limited degree (Thorndike, 1927).

With regard to the first criticism, one feels that this is rather an academic dispute. It is true that it is difficult to evolve a definition of intelligence to which all will subscribe, and it should be freely admitted that our knowledge of the properties of intelligence is limited. One may doubt from a philosophical point of view whether we actually *know* any phenomenon which we encounter in our dealings with reality, whether our concepts in regard to any topic of inquiry are not constantly changing their form as they evolve.

The question of whether or not we *know* the group of phenomena we designate under the term intelligence sufficiently well to measure them must be submitted to the acid test of experience. Do our measurements of intelligence allow us to make predictions which experience verifies? Do we *know* the facts of intelligence sufficiently well to allow us to carry out such successful experiments with them that our results will be in accordance with theoretical predictions? The answer is undoubtedly in the affirmative.

To the claim that we do not test intelligence directly but form an estimate about it on the basis of products of its activity one would say that on reflection there must be few phenomena with which we have *direct* acquaintance and which we do not measure in terms of their activity. Indeed this objection, like the last, seems to date from an earlier and now discredited viewpoint relative to phenomena. While former workers concerned themselves with what a phenomenon *is* — wherein its essence lay — we have come to regard the *is*, the essence, the *Ding an sich*, as intellectual mirages. Our interest in phenomena is what they do and how they do it.

The third objection is rather more valid, for it is true that, if we do not know what a single unit of intelligence signifies, we cannot well state, for example, that a person having a mental age of six is half as intelligent as a person having a mental age of twelve. Similarly, we cannot state the actual relationship of mental ages of six, eight, and ten to each other. Simple observation suggests that it is less difficult to differentiate, on casual inspection, individuals having a mental age of two from those having a mental age of four years, than it is to differentiate those having a mental age of fourteen from those whose mental age is sixteen years. This suggests that the unit of intelligence which we use, namely the mental age year, may vary in value from one age level to another. Attempts have been made to ameliorate this situation. In particular, Thurston (1928) has endeavored to demonstrate a zero point in the intelligence scale. Using absolute scaling methods, he has reported that there is a linear relation between the absolute variability and the mean test performance of successive age groups. From this he concludes that the variability of test intelligence must be zero when the mean test performance is zero. By extrapolation of the linear relationship he found that variability reached the zero point at or shortly before birth and consequently concluded that this also coincides with zero intelligence.

The I.Q., or intelligence quotient, is a convenient index obtained by dividing the mental age in months by the chronological age in months and expressing the answer in terms of a percentage. When the person tested has reached an age at which children tend to leave school, difficulty is experienced in deciding upon a figure to use in place of the chronological age. It is necessary to bear in mind that the test items arranged for any given age level simply represent the tests which the average individual of that age has been found capable of passing. Moreover, the material of most tests is essentially based on school performance. Since interests and experience become much more diversified after school years, and since the sample obtained by testing children in the later school years is invalidated because the duller children leave school, considerable doubt is expressed particularly of the

I.Q. as a reliable measure after the age of fourteen. The part played by possible differential intelligence growth curves will be dealt with later.

From the first, the consistency of the I.Q. has been under the closest scrutiny. The fact that plans are laid for the individual's future on the basis of a belief in the consistency of his intelligence quotient renders knowledge on this point of the greatest importance. In considering the consistency of the intelligence quotient it will be taken for granted that all the more obvious variables, such as emotional disturbances, mental disease and physical illness, have been obviated. To these more acutely-acting variables should be added the more slowly-acting influence of a change from one social milieu to another radically different.

The consistency of the intelligence quotient has been examined for the most part over fairly short periods. Lincoln (1927) tested a group of 30 six-year-old children twice in four hours by means of the Stanford-Binet scale. He found an average change of 1.8 points in the I.Q. E. Brown (1927) stated that there was practically no change in a group of 50 high school students on retest over periods ranging from 6 to 33 months.

A careful survey of the effects of the time interval on the consistency of the intelligence quotient has been made by R. R. Brown (1933). He found that the correlation between the first and second tests became progressively less as the time interval increased. The intervals were from one to twelve years. It was pointed out by the author that taking sixteen as a basis for calculating the I.Q., when the subject was beyond that age, caused a loss of I.Q. points on the part of the group and that the most desirable figure judged by the equality of points gained and lost lay somewhere slightly above fifteen.

The explanation of this has already been dealt with in part. In addition to the factors already discussed, it seems probable that the curve of growth of intelligence varies among individuals.

In confirmation of this point of view, one may cite the investigation of Minoque (1928) who found that in dividing a series of 441 defectives into four groups — under 12 years, 12–15 years, 16–20 years, and 21 years and over — the percentage number of constant I.Q.'s was respectively 62.7, 64.7, 72.4 and 85.8. Her groups were retested at periods from two to ten years.

High correlations for test and retest are given by Terman (1921), 0.96 for 106 feeble-minded individuals below the age of 16; and A. W. Brown (1930) also reports 0.88 for 707 cases ranging from I.Q. 20 to 130. From these observations it is evident that if the grosser variables are avoided and care is observed in the calculation of the I.Q.'s of persons about the ages of 14 to 16, the I.Q. has quite a high degree of consistency. The most frequently noted change in I.Q. is in a downward direction.

Effects of Environment. The nature of previous environment undoubtedly has an effect on the scores obtained on the intelligence tests and it has obviously been presupposed by their designers that those to be tested by them have been exposed during their developmental years to a largely similar environment. Examination of any of the more widely used mental tests will readily show, for example, how a child who has been brought up in a family of foreign origin may produce an unduly low score owing to the fact that he has not had an equal opportunity to acquire vocabulary at home. Later, when greater facility in the use of the test language has been acquired, the I.Q. rises, giving a fictitious appearance of improvement (Hexter and Myerson, 1924).

Similarly, children who have been unduly restricted in their social contacts will return scores that may not do justice to their native intelligence. Ludeman and McAnelley (1930), using the National Scale, investigated two small groups of children who had been brought up without contact with many aspects of what constitutes a modern environment. These children showed themselves capable of returning a good score only when they had had experience with the material on which the test was based.

The question of the precise extent of the contribution which inheritance and environment make to the intelligence of the individual is still not entirely settled. With regard to inheritance it can be readily demonstrated that there is higher correlation between the intelligence ratings of identical twins than between those of non-identical twins. Similarly the correlation between siblings, even when separated by only two or three years, is still less (Tallman, 1928). On the other hand, there is evidence that, if the child is taken from an unsatisfactory environment at an early age, his I.Q. rating will tend to rise with respect to siblings left in the original home or placed unsatisfactorily. This rise does not, save in extreme cases, amount to more than about six to nine I.Q. points (Freeman *et al.*, 1928, Burks, 1928). In summary, it is reasonable to say that available data suggest that intelligence is, to a considerable extent, to be ascribed to inheritance, but that manipulations of the environment which we can contrive result in some variation from the original I.Q. rating.

Growth of Intelligence. No final statement can be made concerning the curve of growth of intelligence. Earlier statements to the effect that intellectual maturity was reached at 14 to 16 years have had to be revised in the light of further information on the effects of the structure of the tests used. It is generally agreed that the method of cross section testing of large groups tends to obscure individual variation to an undue degree.

It is further agreed that the utilization of school groups above the age of 13 to 14 for the purpose of checking the growth of intelligence is faulty because of the fact that the duller children drop out of school and an unrepresentative sample is thus obtained on which to build the test. Finally, since the usual test procedures are so dependent upon the school material to which the subject has been exposed, a further complication arises as soon as part of the adolescent population begins to leave school (Boring, 1935). Clearly it is unreasonable to attempt to assay the intelligence of these adolescents by means of tests based upon school material to which they have not been exposed. At present it is possible only to state the problem and to indicate that great diversity of views exists. Terman and Merrill (1937) report on the basis of the data which they assembled in revising the Stanford-Binet tests that the yearly gain decreases after the age of 13 and practically ceases by the age of 16. On the other hand, Freeman (1936), using special tests and retesting the same subjects over a period of many years, considers that the mental growth curve shows little evidence of flattening out even by the age of twenty. The problem is still further complicated by questions which have been raised as to whether the intelligence growth curves of dull and bright individuals have the same form, whether that of the sexes is identical, and whether the different capacities which are included in tests of general intelligence mature at the same rate (Guilford, 1936).

Little progress has been made in regard to the elucidation of the latter problem, namely, whether there is a differential growth of the various factors upon which an intelligence rating is based. Consequently, though clinical observation frequently suggests it, we are not in a position to state that inability to deal with abstractions, to recognize similarities or to form *Gestalten* from an array of observations, particularly characterizes this or that group of defective individuals.

Decline of Intelligence. In the last two decades a good deal has been added to our knowledge regarding the influence of old age upon the learning function. It has been demonstrated that when learning entails conflict with concepts which are already long established, the aged individual reveals a considerably less adequate capacity to learn than does the younger person (Ruch, 1931). When speed is eliminated as a factor in the test and especially when experience and practice can play a part, the intelligence rating of the individual is well preserved. Miles (1939) reports that, on administering the Otis intelligence rating to a group of 400 adults without limit as to time, the correlations between age and score were: number relations, − 0.26; arithmetical problems, − 0.24; proverbs, − 0.16; analogies, − 0.10; logical selection, − 0.09; vocabulary, − 0.04; synonym-antonym, + 0.01. It can be demonstrated that this relative preservation of the use of language — one of our most practiced activities — is better than that of most other intellectual functions even in the senile psychoses.

Considerable controversy centers around the question of when the decline of intelligence may be said to set in. This period has been set as early as the middle twenties by some workers and as late as the sixties by others. Indeed there is little that has so served to create doubts in the minds of some regarding the validity of the intelligence ratings, at least in adult years, as this matter of the decline of intelligence. From inspection of the data it seems probable that both the learning and the intelligence tests measure phenomena which are correlated with age. These measurements provide excellent correlation with school performance but their correlations with life performance are notably small.

When we consider the fact that during the decades between forty and sixty, when most men by all everyday standards are rising to the height of their capacity, assuming leadership, reaching their highest earning capacity, and at least in the more highly intellectual pursuits are doing their best work, the intelligence tests show that they are gradually regressing to the mental level of a 14-year-old child, then we must seriously question whether these tests measure what they claim to measure at these later age levels. It seems possible that an answer may be found in the fact that the intelligence tests are based primarily on school tasks and on abilities which enable the individual to deal adequately with such material. It is doubtful whether they deal nearly so adequately with the ability to incorporate experience and to acquire thereby that greatly increased range of response and ingenuity in managing problems which renders the man of forty more capable than the adolescent of sixteen of dealing with life situations.

Effect of Disturbance at the Higher Functional Levels. It was stated earlier that scores obtained either by the learning tests or by the intelligence tests showed a positive correlation with many other activities carried on at the higher functional level. It is therefore natural that disturbances of these other activities should affect the scores obtained by these techniques of measurement. This interference may be present in a transient form during embarrassment, fear or anger, or it may be present as a more permanent factor, as in the pathological mood disorders, or when there has been destruction of brain tissue.

The strangeness of the interview or the circumstances under which it is carried out may have profound influence on the result. It has been shown, for example, that fear, anger, embarrassment, sex interest and repulsion, in order of decreasing efficacy, may cause interference with the performance of simple arithmetical problems.

The presence of frank behavioral disorders may produce various types of disturbance with performance of the intelligence tests. The most outstanding of these are a general reduction of capacity, a reduction in capacity to deal adequately with certain components of the tests, and "scatter," which is largely a product of the second type of disturbance mentioned. It is particularly in those cases in which extensive damage to brain tissue has occurred that a general reduction may be expected, though the inhibition associated with depression may result in a considerable lowering of score due to the fact that the majority of test instruments are devised at least in part to function on the basis of speed of performance.

In the schizophrenic reaction there is frequently a progressive reduction in capacity as indicated by the intelligence rating. This reduction is to some degree differential: old knowledge such as the proper use of language is well preserved, but test items based on the capacity to form new concepts reveal a definite deficit. This type of differential response may be present in the early stages of certain forms of organic disease such as paresis. In this condition difficulty in dealing with such abstractions as mathematical symbols is particularly marked and may constitute an early evidence of the disorder. Improvement in the condition is accompanied by improvement in the rating (Kaufmann, 1929).

Work on the problem of scatter has shown that this phenomenon does not promise as much as it was thought once it might. It was at one time hoped that scatter — the tendency to score in a series of age levels above the basal — might have considerable value in the detection of incipient mental disorders. Statements to the effect that scatter over a five-year range, including the basal, is indicative of disturbing factors are true only to the extent that similar scatter may be found in otherwise normal individuals. Further clarification may possibly be obtained by studying the isolated items which are successfully accomplished. Such studies tend to lead back to the observation discussed earlier, namely, that in individuals suffering from a mental disorder there is a differential failure in the intelligence tests.

There is some evidence to suggest that, in groups of normal individuals and psychotic individuals who show scatter, the successfully accomplished items in the scatter range represent activities which are different for the psychotics and the normals. In the former the successfully accomplished items are usually based upon old knowledge. Recent work suggests that, so far as comparison between scatter in normals and schizophrenics is concerned, the degree of scatter is more highly correlated with mental age than with psychotic condition (Harris and Shakow, 1938).

Effect of Disturbances at the Lower Functional Levels. Since the learning function is simply one aspect of the general activity of the organism, it is clear that any serious disturbance of the general functioning will produce interference with the capacity to learn. Consequently, one finds that serious variations from homeostasis such as occur in hyperglycemia or in anoxemia will produce reduction in the ability of the organism. With regard to the latter recent work on men living at high altitudes and in low pressure chambers has shown that the speed and accuracy of intellectual activities are much reduced. With decreasing oxygen there is an increased tendency to perseverate and a progressive loss of concentration. This process is the more serious since the individual is rarely aware of its occurrence (McFarland, 1937). The breathing of 10 per cent O_2 has been reported as producing a definite drop in performance on the Army Alpha test (Kraines, 1937). It is of interest to note that work carried out under increased O_2 tension likewise reveals an increased tendency toward error and delay (Shilling and Willgrabe, 1937). Improvement of capacity is rarely found as a consequence of interference at the lower functional levels. Experiments with cocaine, caffeine, and strychnine have tended to demonstrate that while speed of performance might be increased, accuracy was usually decreased. Recent studies (Sargent, 1936; Molitch and Eccles, 1937) suggest that some increase in the score obtained in intelligence tests might be obtained by the administration of benzedrine sulfate. Since speed of performance is a factor in scoring these tests, further work is required to clarify the question of whether there is a real increase in power while under the influence of this preparation.

Performance at the lower functional levels and learning capacity are positively correlated. Individuals with low I.Q.'s are more likely to present physical defects than those having I.Q.'s within the normal range (Dayton, 1929, 1930). This correlation extends to the state of general nutrition. Children who are undernourished tend to show a slower performance and a greater fatigability (Nicholls, 1923).

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CHAPTER IV

MEMORY

For the purposes of investigation memory is customarily considered in three phases — registration, retention, and reproduction. This concept of the function of memory has many defects. It clearly originates from a period of our thinking about memory when memorized material was considered much more analogous to a written record than we now believe it to be. To continue the analogy it was formerly considered that part of the record might become effaced in time, part might become lost, but there was no conception of the probability that the record might be largely rewritten or that several versions might actually come to coexist in the same individual. Furthermore, there was more certainty than there is now that the memory traces, so far as they were retained, consisted in changes produced in association fibers through which the perception of the original happening was considered to pass.

We propose, however, to preserve the concept since the three phases do represent activities or more probably groups of activities which have a chronological relationship to each other.

Registration. Consideration of the activities carried on during this phase demonstrates the force of what was said in the preceding paragraphs, namely, that the function of memory is far from being comparable with any mechanical method of registration and preservation of happenings. All happenings seen over the same period are not equally registered, and it appears that in some instances what is seen may not be registered at all.

Extensive data are available to demonstrate that in learning a series of nonsense syllables the first and last members of the series are much more easily learned than are those in the middle. Similarly, it can be shown that a much larger number of items can be recorded if the items can be arranged in meaningful groups. The question whether a reduction of this capacity to conceptualize meaningful patterns in large arrays of items may be a factor in the impoverishment of memory in organic brain conditions awaits further work. It can be shown, however, in persons suffering from the psychoses of the senium that perseveration may become so accentuated that if two objects are shown to the patient in immediate succession, the second may not be apperceived. At best the second may serve as a stimulus to revive the image of the first object (Cameron, 1940).

Similarly the existence of social stereotypes — preconceived ideas, arising from the cultural background or from the individual's past experience, as to how things happen or what things are — may also prevent our seeing, or apperceiving, what is happening under given circumstances. We tend to recall not only what we have experienced but what we believe we ought to have experienced (Moore, 1935). In considering the phenomena which occur during this phase of the memory function, it is clear that our investigative techniques do not permit us to separate at all clearly the activities of this phase from those going on during retention or reproduction. At best we can say that since these factors appear to operate immediately on presentation of the data to be memorized or as soon thereafter as we can test for them, it seems reasonable to consider them as interfering with the process of registration.

Certain other factors should be mentioned in connection with this phase of memory function. It is by no means certain, however, that their effect is exclusively upon those activities occurring during this early stage in memorizing. The first of these factors consists in emotional disturbance of the organism at the moment of presentation of the data. From work which has been done on testimony it seems probable that this disturbance exerts what may be termed a focusing influence upon the capacity of the organism to register. Those things which lie directly in the center of the attention may be adequately registered, but those more peripheral occurrences which, when the organism is emotionally indifferent, are usually well registered, may leave little or no impression. It is clear, however, that even if we test the registration by having the subject attempt to reproduce the data as early as possible after presentation, we are nevertheless dealing with the reproduction of the circumstances surrounding an incident of emotional significance to the organism and it will be difficult to differentiate between failure to register and the inhibiting effects of the central incident upon reproduction of the surrounding circumstances.

A second factor consists in disturbances at the lower functional levels. As was indicated earlier, the higher functions cannot be adequately carried out unless homeostasis is preserved within certain narrow limits. Consequently, in conditions such as alcoholic intoxication, anoxemia, or profound disturbances of the acid base balance, registration may not be adequately achieved.

Retention. Of the three phases of memory which are described retention is clearly the most definitely misnamed. Work which has been reported from the time of Ebbinghaus has clearly shown that alongside those activities which make for the retention of material which has been registered, other and perhaps more active processes are at work which make for the distortion of what was originally recorded. This distortion can readily be demonstrated by the method of serial repetition which was first extensively used by Phillippe (1897) and has since formed the basis of techniques devised by numerous workers. Utilizing this procedure it can be shown that the data, as originally recorded, undergo progressive change with each repetition. If the repetitions are carried out in immediate succession, a more or less final modification of the data as originally presented is produced, but if the repetitions are carried out at long intervals the process of modification may be continued indefinitely. Two major processes which contribute to the modification are those of rationalization and conventionalization. The former consists in a constant endeavor on the part of the subject to make the originally presented data meaningful. This is demonstrated in experiments on the serial reproduction of legends drawn from cultures foreign to that of the subject. Here one finds the introduction of connections to render apparently disconnected parts of the story more meaningful, and the gradual transmutation of bizarre data into forms which are meaningful for the individual.

The process of conventionalization is somewhat similar in its action since it tends to produce change in the original data of such a kind that it will conform not only to the subject's previous experience but also to the culture to which the subject belongs (Bartlett, 1932). These activities may result in the most extensive alteration of data — transposition, omissions, multiplication and actual reversal of meaning. As can be readily seen, these activities correspond in some degree to those described by Freud as leading to the secondary elaboration of dreams.

This process of secondary elaboration has been shown to proceed with greatly increased rapidity in certain of the organic psychoses. Work has been done especially in the Korsakow psychosis (Bender, Curran and Schilder, 1938), and the psychoses of senium (Cameron, 1940). In the case of the latter it seems that this greatly accelerated secondary elaboration, together with the increased tendency to perseverate which was referred to in the discussion of registration, plays a considerable part in the severe involvement of recent memory which one finds in these psychoses.

Our knowledge of the factors which influence retention is still limited. Those facts which are available indicate that sleep influences retention considerably. If the data are memorized immediately before a sleep period of several hours duration retention of the data will be considerably better than if a period of several hours is permitted to intervene before the patient sleeps. Recent work with rats suggests that in these animals retention of maze learning is impaired by a lack of Vitamin B_1 (Poe, 1937). This is of particular interest in view of the claims made for the use of Vitamin B_1 therapy in patients suffering from Korsakow psychosis.

Head injuries, especially if there is an extensive destruction of cerebral tissue, may be accompanied by a considerable loss of memory not only for the event and immediately subsequent experiences, but also for a period preceding the injury. In view of the work which has been done to determine how far this memory loss can be cleared up under hypnosis, it cannot be definitely stated to what extent we are dealing with a failure in retention or a failure in reproduction.

Reproduction. It is a matter of common experience that fluctuation in the capacity to recall or reproduce may occur. It is within the range of normal experience to find that data which cannot be recalled on one occasion can be readily produced on a later occasion without opportunity for relearning having occurred in the interval. Similarly, the much more serious and extensive amnesias which occur in hysteria can clear up in a similar manner. Even those amnesias which are associated with post-convulsive states, and to a lesser extent those associated with head trauma, may show great improvement if suggestion is utilized.

Undoubtedly part of the memory loss found in organic brain conditions is due to a failure to reproduce. This can be readily demonstrated by applying the criterion referred to previously, namely, whether the patient is able to produce without further experience material which he could not bring out on an immediately preceding occasion. A further point of evidence consists in noting that these patients can often recognize the correct data even though they are not able to reproduce it unaided. We have already referred to the fact that, in patients suffering from psychoses of the senium, there is frequently a failure to register and to retain, and we have also pointed out that in the Korsakow psychosis a greatly accelerated tendency to secondary elaboration interferes drastically with retention.

The factors responsible for failure to reproduce are not fully known. Two processes are certainly active. The first is retroactive inhibition (Britt, 1935). The nature of this activity can be demonstrated by various techniques. One of the most satisfactory is to have the subject learn a list of words, and shortly afterward have him memorize a list of synonyms. He is then asked to reproduce the first list. He is then given a third list to memorize followed by a list of non-synonymous words. Comparison of his reproduction of the third list with the first will demonstrate that the synonymous character of the second list has resulted in a reduction in his capacity to reproduce the words of the first list. This process is described as retroactive inhibition.

A second factor consists in the tendency of the individual to reproduce more readily events having a pleasant significance than those of an unpleasant nature. This factor has been extensively utilized by the psychoanalytic group in explanation of psychoneurotic behavior. Experimentally it has been demonstrated frequently by contrasting the ability with which lists composed of words having an unpleasant meaning for the subject and lists of words of pleasant significance can be reproduced. There is a definite difficulty in reproducing the words having an unpleasant significance (Sharp, 1938).

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CHAPTER V

THE FUNCTION OF CONDITIONING

PROBABLY the most valuable and most productive contribution which animal psychology has made to psychiatry consists in the work upon the conditioned reflexes. Though the name of Pavlov (1928) is almost universally associated with the conditioned reflex, it must be remembered that at the time Pavlov was engaged upon observing the secretory conditioned reflex, Bechterew and his co-workers were independently elaborating the concept of the motor conditioned reflex.

The first step in the building up of the whole structure of the work upon the conditioned reflex may be said to have been initiated by the observation that the secretion of the digestive glands and especially that from the salivary glands took place when food was perceived by the animal, usually a dog, and before it had had time to come in contact with the buccal surfaces. It was observed, moreover, that the type of saliva depended upon the type of food; for dry bread the secretion was copious and watery, for moist foods there was little salivation and for acids a thick saliva, designed to protect the buccal mucous membrane, was produced. The next step was the observation that procedures which were associated with the giving of food to the animal, acquired with repetition the capacity to elicit the flow of saliva. This last observation was finally brought down to an experimental procedure in the form of the association of a bell, a light, or a skin stimulus with the giving of food. It was found that any stimulus, no matter how indifferent, could through association with the giving of food acquire the capacity to induce a flow of saliva. This indifferent stimulus is known as the conditioned stimulus; the sight of the food is known as the unconditioned stimulus. The capacity of the conditioned stimulus to provoke a flow of saliva is dependent upon the conditioned stimulus being followed by the unconditioned stimulus. Where this latter is consistently omitted the conditioned reflex, as the flow of saliva in response to the conditioned stimulus is termed, grows gradually less and finally disappears. The conditioned reflex suffers extinction, as Pavlov terms it.

While the salivary reflex in the dog has been most widely used as an instrument of analysis, probably largely because of the ready manner in which the findings from its study can be reduced to quantitative terms by means of measurement of the saliva produced, the study of the conditioned reflex has been carried out in other animals also and on the basis of other reflexes. Frober (quoted by Gantt, 1932) has examined the motor reactions of fish to the passage of an electric current, using as his conditioned stimulus a red light, a green one being employed as a negative conditioned stimulus. After a considerable number of trials a conditioned reflex to the red light was developed, and at the same time the fish showed no response to the green light. Krasnogorski (1933) has worked upon motor reflexes with children, a topic which will be taken up later.

At this early point it will become quite clear that the simple fact that indifferent stimuli can acquire, through association, the potency to produce reactions believed to be the prerogative of certain well-defined stimuli is a fact of great interest not only to psychology but also to psychiatry. This impression is reinforced by the fact that Watson has shown that not only motor and secretory but also emotional conditioned reflexes can be built up.

Pavlov next advances to the concepts of irradiation and inhibition. By inhibition he designates the capacity of stimuli to extinguish the conditioned reflex. There are two types of inhibition, external and internal. The former is analogous to that described by Sherrington (1923) as spinal inhibition and consists in the struggle of two activities for dominance. The entry of a new-comer to the room, or an outside noise occurring while the reflex is being elicited, may be sufficient to inhibit the development of the reflex. It is for this reason that great care must be observed to exclude all extraneous stimuli in carrying out work upon the conditioned reflex.

Internal inhibition, so called because it occurs within the activity under consideration in contradistinction to the external which consists in the interference by an outside activity, may be produced simply by omitting the conditioned stimulus consistently to the point where the conditioned stimulus no longer produces a reaction. A second form of internal inhibition arises when, in the case of an animal in which a conditioned reflex to the conditioned stimulus *A* has been built up, a stimulus *B* is presented simultaneously with *A*, but when the two stimuli are used simultaneously the unconditioned stimulus is not given. After a few trials the reflex is extinguished whenever *B* is added to *A*. It is now found that if *B* is combined with other conditioned stimuli it will produce its inhibiting effect.

The phenomena of internal inhibition are thought by Pavlov to be clearly related to those of sleep; indeed he states that sleep consists essentially in an inhibition which has become widespread. In eliciting internal inhibitions it was frequently observed that the animals showed drowsiness and sometimes actually sleep. This is especially to be observed when there is a delay in following up the conditioned stimulus by the unconditioned stimulus or when the reflex has been extinguished and the now no longer potent conditioned stimulus is repeatedly made. Pavlov enunciates a general proposition that more or less continuous stimulation of a part of the hemisphere, if not accompanied by or interrupted by other stimuli, will eventually lead to drowsiness and actual sleep.

With regard to irradiation Pavlov made the following interesting observations. In the case of a dog in which numerous skin conditioned reflexes have been built up through stimulation of which equal amounts of saliva can be provoked, the following phenomena may be shown. When one of the reflexes is extinguished by failing to follow up the conditioned stimulus by the unconditioned stimulus, the normal response may be obtained by stimulation of one of the other points, provided the stimulation takes place at once after the first. Should one interpose a delay of a few seconds between the stimulation of the first area in which inhibition has been developed and the stimulation of the second, the amount of saliva secreted will be reduced and it will be reduced in amount depending upon the number of seconds which have elapsed after the stimulation of the inhibited area. If one allows an appreciable interval, for example thirty seconds, to elapse complete failure to produce saliva may follow upon stimulation of the second area. The lapse of still further time is followed by gradual return in the amount of saliva to be secreted by stimulation of the second area, until there is finally a return to full secretion. It was noted also that a reduction in secretion manifested itself more slowly the greater the distance of the second part from the first.

To explain these phenomena Pavlov suggests that we regard, in this respect, the skin as a projection of a certain area of the brain. The stimulation of the original skin area in which the conditioned reflex has been extinguished by the development of inhibition results in the production of a focus of inhibition in the brain which radiates out over the brain mass in an apparently concentric manner, involving progressively those points that lie in spatial sequence from it. This process is followed by the process of concentration during which this phase of inhibition undergoes contraction again, thus progressively freeing in the reverse order the areas which it had involved and ultimately coming to involve only the original area where, however, it may be present for a considerable time.

Pavlov makes the further observation that while the speed of radiation and contraction varies considerably from animal to animal it is remarkably consistent in the same area. Excitation shows the same phenomena of radiation and concentration.

Another function of importance is that of differentiation. When the indifferent stimulus is first established as a conditioned stimulus there is little selection within the field of the particular stimulus. Should a metronome be employed as the conditioned stimulus, it will be found that considerable ranges in the vibration frequency suffice to elicit the reflex; likewise when a pin prick is employed, it will be found that pricking of almost any area of the skin will produce a response. With frequent employment of the reflex, however, considerable differentiation is established until, apparently by a process of inhibition of other stimuli, there is response only to a very specific stimulus. Pavlov notes that it is possible to obtain such differentiation that there is no response to a metronome, the frequency of which is only a few beats faster or slower than the one upon which the reflex has been built.

A considerable amount of work has been directed toward delimiting the range of activities in which conditioning may be set up. In particular, attempts have been made to condition biochemical responses. These have been unsuccessful save where the biochemical response has been directly or indirectly under the control of the central nervous system. Investigations into the question of which aspects of the central nervous system are particularly important with reference to conditioning have corroborated Pavlov's original contention that in the higher vertebrates the cortex is essential to conditioning. Even when the activity of the effector apparatus is temporarily abolished or when the unconditioned stimulus is applied directly to the sensory cortex, conditioning can still be established (Gantt, 1937).

The approach to the psychiatric application of these fundamental laws is perhaps best made by noting that temperamental differences are to be observed in dogs brought under experimental procedure. It was possible to distinguish readily an aggressive type of dog which had to be handled with care lest he should turn even upon people who were well known to him; at the other end of the scale was the dog who cringed before every unusual circumstance and who slunk away even from the workers who had been engaged with him over periods of months. Definite differences were found in the formation of the conditioned reflexes in these two types. In the aggressive dog, while excitory reflexes would be easily set up, the inhibiting reflex was hard to form and was readily abolished. This type of dog Pavlov refers to as excitory. In the cringing cowardly type, inhibiting reflexes were easily formed and were found to be very stable. On the other hand, excitory reflexes were difficult to build up. This type of dog has naturally been termed the inhibitory type.

Between these two types there is a central group in which both inhibiting and excitory reflexes are quite readily formed and in which they remain stable. This central group, too, is susceptible of further differentiation, for it is composed of two groups of dogs, the one, quiet and self-contained, the other, lively and active as long as stimulated by their environment, but when no longer stimulated rather readily falling asleep.

Pavlov considers that there is an analogy between these types and the well-known temperaments as delineated by Hippocrates. For him the excitory type is the choleric, the inhibitory is the melancholic, and the two central groups are the phlegmatic and the sanguine respectively.

It has been possible in the excitory and inhibitory types of dogs to produce pathological states by experimental means. If processes of excitation and inhibition are brought together in such a way that a "collision" occurs this will be followed by the development of pathological behavior which differs for the two types. Such a collision is produced, for example, when the conditioned stimulus takes the form of the sound produced by a metronome of definite frequency. Negative conditioned stimuli in the form of greater frequencies are built up. If a metronome of a frequency lying between that of a negative and positive conditioned stimulus is employed, an abnormal reaction may be set up. The same thing may occur whenever the one type of stimulus is immediately changed into the other. When this "collision" occurs one finds that in the case of the excitory type all inhibiting reflexes are lost and the dog passes into a state of continuous excitation both while in the experimental surroundings and out of them. Pavlov likens this to neurasthenia. In the case of the inhibitory type, such a "collision" results in a loss of the excitory reflexes and a predominance of inhibitory reflexes. Pavlov finds analogies between this state and that of hysteria. The former neurasthenic state yields in a week or two to treatment in the form of bromides and calcium salts. For the other, however, little avails save prolonged rest from experimentation.

The central types show no ill effects from this procedure. On more theoretical grounds Pavlov considers the possibilities of a similarity between the mechanism of schizophrenia and that of the inhibitory type, and between the mechanism of the cyclic psychoses and that of the excitory type.

Since Pavlov's original work upon the experimental neurosis this field has been considerably developed by various other workers. It is important to note that though a considerable range of animals — dogs, cats, doves, sheep, pigs, rats — have now been used as subjects in these experiments, the same fundamental principles of production of the neuroses are applicable in each of the types of animals mentioned. Moreover, it has been shown that by utilizing these same procedures with caution some of the earlier symptoms shown by these animals could be produced in children (Krasnogorski, 1925). This universality of response is of theoretical interest, since quite apart from the question of whether the experimental neurosis is comparable to what is encountered clinically, it affords further evidence on behalf of the contention that the fundamental behavioral responses of a considerable range of animals including man are comparable, and that therefore we may hope to benefit from the experimental study of animal behavior as we have from the study of animal physiology.

The procedures which have been found generally effective in producing the experimental neuroses are first of the type already mentioned, namely, when the animal is forced to make a finer and finer discrimination between a stimulus ordinarily eliciting an excitatory response and one eliciting an inhibitory response, as, for example, when a conditioned stimulus which produces one phase, *e.g.*, excitation, is immediately followed by a conditioned stimulus which produces the opposite phase. A second type of procedure consists in interposing a longer and longer interval between the conditioned and the unconditioned stimulus. Experimental neuroses have also been produced in the process of developing inhibition of a strong inborn unconditioned response. Finally Pavlov has reported that very strong stimulation may produce a neurosis as in the much cited instance when the dogs of his experimental laboratory were involved in a dangerous flood and had to swim to safety.

The behavior which has been described as neurotic usually appears both in the experimental situation and apart from it. In the experimental room the animal may be restless, apprehensive, and antagonistic. Refusal to eat in the experimental situation has also been noted. Such animals frequently show considerable change in behavior even when not undergoing investigation. They may be noticeably more restless, and show definite emotional changes, usually in the direction of increased irritability and apprehensiveness.

Once established these conditions are often hard to correct. So far two methods have been demonstrated as of value. The first consists of prolonged rest — in severe cases this may have to be reckoned in terms of years; the second involves the use of bromides. This drug is considered to act by localizing the inhibitory process and thereby releasing the rest of the cortex. It is of interest to note that unfortunately little progress has been made toward evolving a means of treatment of the experimental neurosis based upon the laws of conditioning.

Interest has been directed toward attempts which have been made to find common ground between the concepts evolved by psychoanalytical procedure and those of the conditioned reflex. French (1933) in an able paper upon this topic endeavors to show that there are analogies and even similarities between the two bodies of evidence. He suggests that inhibition may be largely read for repression, and that there is much comparable in the Pavlovian concept of differentiation and the Freudian sublimation. There is need of experimental verification of this viewpoint.

Comparisons have also been made between the conditioned reflex and habit formation. It is pointed out that old-established conditioned reflexes are much more stable than the more recently elaborated ones, and that there is an analogy between this and the fact that habits acquired in later life are not nearly so stable as those formed in youth. Further, it is pointed out that, just as a conditioned reflex once extinguished is upon re-establishment never again so stable, so a habit once broken is hard to restore to its former reliability. Gantt (1932) endeavors to bring these observations into line with James' dictum upon habit formation. The latter urges that habits should be made as early as possible in the life of the individual and that the greatest care must be taken not to allow an exception to occur until the habit has become well established.

From the work upon conditioned reflexes in children several interesting facts emerge. It is apparent that the speed with which reflexes are formed is in part a function of the intelligence of the child. Gantt quotes Krasnogorski as having found an idiot child as slow in forming conditioned reflexes as a fish. In general, children form reflexes much faster than do dogs, twenty-five repetitions of the procedure sufficing in the child as compared with thirty to one hundred in a dog. On the other hand, the reflex is extinguished much more easily. While in the dog it is possibly usually only to interpose two or three links in the chain of the conditioned reflex, in the child considerably larger chains can be evolved so that the conditioned stimulus may be quite remote from the unconditioned stimulus. Hence the Pavlovian suggestion that one may be able to view behavior from the point of view of the conditioned reflex.

Ivanov-Smolensky (1927), by means of a grasping conditioned reflex, has noted that it is possible to distinguish three groups of children — a group, that is relatively stable, in which both positive and inhibitory conditioned reflexes can be readily formed, a group with poor internal inhibition, and a group in which inhibition is more marked than excitation.

Desensitization. The matter of desensitization is considered separately from conditioning since our present information does not permit us to state that the mechanisms involved in both functions are identical. It is clear that the activities designated are almost continuously at work and that they are most necessary to the organism. We are universally familiar with the fact that we are emotionally aroused by day to day experiences and with the fact that the recollection of these experiences may also arouse us emotionally. Fortunately, each subsequent recollection as a rule arouses a briefer and less intense emotional reaction until finally recollections which once aroused strong emotional responses now barely stir us. Clearly if this process of desensitization did not exist the individual would be in a state of almost continuous emotional uproar. It seems probable from simple observation that a similar process of desensitization is at work in certain depressions such as those centering around pathological guilt reactions.

There is still ground for reserving judgment as to whether desensitization is identical with extinction in the Pavlovian sense. In the first place, it is not certain that the acquisition of the sensitivity is necessarily accompanied by a process of conditioning. English (1929), in discussing the acquisition of fear responses, points out that the response is usually acquired after a single experience in contrast to the conditioned reflex which requires, as a rule, that the experience should be reenacted several times. The work of Jones (1924) on what was termed the deconditioning of children suffering from morbid fears could more satisfactorily be considered as adaptation though her procedure was clearly derived from conditioned reflex concepts. In these investigations the stimulus to which the child was to be desensitized — in this case the appearance of a white rabbit — was repeatedly displayed while the child was engaged in a fundamental and pleasurable activity such as eating. Eventually all fear of the displayed object was lost. It may be reasonably argued that, since at the time of acquisition of the response an emotional reaction was elicited, the speed of acquisition was increased. It is well known that the elicitation of an emotional response by punishment increases, to a certain point, the speed of learning in animals.

While repetition of a stimulus producing an emotional response usually results in a diminution of that response this may not be so when the stimulus is complex. Under such circumstances the response may even be increased temporarily, this being possibly due to fresh aspects of the stimulus being grasped upon subsequent repetitions (Davis, 1934). This seems also to have been true of the investigations of Rasmus (1936) upon the degeneration of the emotional response on re-showing of motion pictures.

Apart from that already described in connection with the morbid fears of children, comparatively little work has been done in connection with pathological variations in the process of desensitization. May (1934) and Shipley (1934) investigated the speed of desensitization in certain abnormal conditions, the chief emphasis being upon catatonia. They found that the speed was greatly reduced, and they were disposed to consider this evidence of an increased tendency to perseverate. The earlier definition of perseveration as the tendency which an activity shows to return to consciousness might justify the explanation offered by May and Shipley but the more recent formulation of perseveration as the tendency to persist shown by an activity when once initiated renders their explanation less tenable. Hoagland, Cameron and Rubin (1938) were able to produce desensitization to painful former experiences in a number of paranoid and depressed patients. The desensitization was recorded by means of the pulse rate and by means of the degree of disturbance in the brain wave pattern. It is to be borne in mind, however, that this desensitization was acquired only in a given situation and there is no reason to think that the presentation of the painful topics by other persons or in another setting might not once more elicit an emotional reaction.

A great many even of the more fundamental problems concerning desensitization are still unsolved. We know little of the neurophysiological levels at which it occurs. The question of whether it requires the participation of the higher cerebral levels or whether it can be carried out at the thalamic level is still unexplored. Similarly, we know little concerning the factors which facilitate desensitization. Common experience suggests that the nature of the events which immediately follow upon the painful experience is of importance. Smith (1934) reports that fears can be "deconditioned" best within twenty-four hours after their development.

Finally we do not know how far recovery from a painful experience is due to desensitization in the strict sense of the word, *i.e.*, loss of capacity of the recollected experience to provoke an emotional response and how far recovery is due to the ability of the individual to isolate the memory so that it is rarely touched upon during day to day experience.

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CHAPTER VI

FUNCTIONS OF THINKING AND LANGUAGE

WORK in this field is still hampered by lack of clearly defined concepts and by lack of experimental methods.

It is generally agreed that thinking is a complex function involving among other, as yet poorly defined, activities the use of images and of concepts. It is moreover accompanied by more widespread activity of the whole organism than casual observation might suggest. It has been demonstrated, for example, that mental effort is usually accompanied by increased muscular tone and that in certain circumstances, though by no means in all, the distribution of muscular tension can be correlated with what is being thought. This is well exemplified by the fact that, on the one hand, the individual who is thinking intensely about the playing of a game will frequently show increased tension of those muscles used in the game while, on the other hand, the tension accompanying an intense intellectual effort in the field of mathematics is quite unspecific though it may be just as great.

There is no evidence that active mentation is accompanied by an increase in the oxidation rate. By analogy with other organs, however, it seems unlikely that an organ which is capable of a considerable range of activity should not also show a range in the intensity of its energy exchanges.

Electroencephalographic studies have also thrown comparatively little light upon the matter of thinking. There is no general consensus that the brain wave pattern differs if the patient is simply passively attentive or if he is engaged in intense mental activity, provided that his emotional attitude remains indifferent in both instances.

Concept Formation. As previously mentioned, much of the complex function of thinking does not yield readily to experimental procedure. Provisional techniques have been worked out which enable investigation of certain aspects to be carried out. In particular the procedure originally introduced by Ach (1921) for the study of concept formation has been elaborated to a point where it provides a fairly satisfactory means of dealing with some of the problems of concept formation as we see them at present. Essentially the method consists in the presentation to the subject of a large number of apparently heterogeneous objects. His capacity to form concepts is based on his ability to allocate the objects to categories on the basis of underlying similarities which are not immediately obvious.

This technique has been used particularly in studies of the use of concepts in schizophrenia (Vigotsky, 1934). This type of experimental investigation in the hands of several workers (Kasanin and Hanfmann, 1938) has tended to confirm the opinion long advanced that the thinking of schizophrenics differs considerably from the normal in the use of concepts. It is found that while the normal adult forms concepts concerning a series of objects on the basis of attributes which are common to groups within the series, the schizophrenic individual links objects together on the basis of proximity or on the basis of characteristics which, for example, the first and the second, and the second and the third objects in a series may have in common but not the first, second, and third (Cameron[a, b], 1938).

In patients suffering from organic brain injuries it has been found (Goldstein, 1936) that there is considerable difficulty in manipulating concepts. (*See* section on structural function.) The individual is able to recognize objects put before him and may be able to reproduce them in the same setting. However, if the patient is asked to draw in another setting a reproduction of the figure shown or if he is asked to draw an enlargement of the figure or an inversion of the figure great difficulties may be experienced. The patient is able, as a rule, to form a concept of the object shown but is unable to form further concepts of the object withdrawn from its setting or concepts in which the figure might form the basis for new though clearly related figures, *e.g.*, a right-angled triangle three times the size of the original or one in which the base takes the place of the apex.

In old age characteristic changes occur with respect to the ability to form and to work with concepts. When the data to be conceptualized are clearly related to that with which the subject has dealt all his life there is little loss of ability. However, when the material is new loss of capacity is encountered. The actual utilization of concepts as in reasoning and in the forming of judgments is usually well preserved into the later years. The loss of speed consequent upon aging may give rise to a spurious impression of loss of ability, but if this variable can be eliminated, surprisingly good scores can be obtained from aged persons (Miles, 1939).

Use of Images. Problems connected with the formation and activity of images have been investigated mainly from the psychological point of view. Little work has been done upon the psychiatric implications in this field save in so far as a relationship may exist between images and hallucinations. It has frequently been pointed out that the difference between the mechanism of hallucination and that of the formation of images is not great. For example, it is quite a normal experience in listening for the ticking of a clock to project an auditory image of the sound in instances when the clock has actually stopped. Similarly it is possible to project images of non-existent objects, especially at night (Boring, Lungfeld and Weld, 1935). This experience of the projection of images is particularly common in those individuals who have a well developed eidetic imagery. In such persons it is possible after careful scrutiny of a scene or a picture to project it in considerable detail when asked to look at a neutral background.

Hallucinations. Extensive use of drugs has been made in the study of hallucination. Of these the most common is mescalin. Under the influence of this preparation a considerable range of visual hallucinations can be produced particularly in dim light.

The hallucinations are usually of a rather simple type during the early stages of the action of the drug; later they tend to become organized in conformity with the experience of the subject. A particularly interesting phenomenon consists in the appearance of synesthesia during mescalin intoxication. Several workers have reported that sounds have produced colored hallucinations while colors have been found on occasion to produce gustatory hallucinations (Klüver, 1928). Various suggestions as to the mode of action have been advanced. A careful investigation by Marshall (1937) suggests that the choriocapillary circulation may be primarily responsible for the frequency with which the mescalin hallucinations take the form of mosaics, lattice designs and geometrical forms.

Hallucinatory activity has been described as occurring in connection with a very extensive series of brain lesions — lesions of the parietal lobe, of the occipital lobe, of the peduncles, of the red nucleus and even of the cerebello-pontine angle. Studies of such cases have not, however, thrown much light upon the mechanism of hallucination. A third approach has consisted in the production of hallucination under the influence of hypnosis (Erickson and Erickson, 1938). That this can be successfully achieved is attested by the appearance of negative after-images when color hallucinations are suggested to the subject. It also renders clear the fact that all hallucinatory activity does not depend upon the presence of an actual organic lesion.

The problems of delusion formation have not been reduced to experimental terms. Indeed at present there exist comparatively few promising approaches. The most likely seem to consist in the study of beliefs and in the effects of emotional reactions upon concept formation.

Language

It is clear that considerable difficulty exists in the way of effecting a definite distinction between thinking and language, at all events, from the point of view of methodologies of experimentation. Since we propose to use the term language in a broad sense, including within this term what is commonly understood by speech, we feel justified in considering thinking and language in separate categories.

At the outset it is desirable, for purposes of orientation, to make some statement with reference to the evolution of language and its value to the individual. The first problem is exceedingly difficult since the early developments of language have left few traces. It seems reasonable, however, to find some basis of comparison with the cries of animals and to ascribe the immense differentiation of human language as being due to the value which it has had in permitting integration of individuals into group organizations (deLaguna, 1927).

The various steps which comprise the development of the function within the individual are by no means clearly understood. Two concepts which represent definite progress in this direction are first the postulate that the growth of the language function cannot be understood as a simple additive process. The use of words is not acquired by a simple addition of new words but must be looked at from the Gestalt point of view. The second postulate, which represents a decided advance, is that the function of language cannot be considered apart from the organism but must be thought of as an expression of the total organism (White, 1930).

Development of Language. Extensive work has been carried out upon the development of the function of language in children. The earlier studies were largely directed to a consideration of the appearance of such grammatical forms as are already known to exist in the language of adults. This procedure has been relatively sterile. More recent investigations have tended to focus attention upon the behavior content of the words used. It has been shown that the very earliest words which are employed by young children are actually word sentences; for example, the utterance of the word "ball" rarely constitutes the simple designation of a near-by object but usually is to be interpreted as "give me the ball."

It is found, moreover, that the young child has few words of an abstract nature; his vocabulary consists largely of words designating objects which he sees and more particularly the action and uses of those objects (Markey, 1928). This worker also refers to an earlier study by Barnes (1896) in which the latter collected the responses of 2,000 children between the ages of 6 and 15 to a list of words. On analysis it was found that at the age of 6 years the definitions of the words were in terms of use or action, in 82 per cent of cases, while at 15 use and action appeared among the definitions in only 33 per cent of the total. The remaining definitions were in such terms as substance, structure or classification.

Interest has also been directed toward the appearance and utilization of the personal pronouns. The first person pronoun appears about the 23rd month and the second at about the 24th month. The appearance of these words is of particular importance with reference to the growing capacity of the child to differentiate himself and his activities from those around him (Markey, 1928). It indicates the beginnings of social differentiation and the early stages of concepts of group formation. These studies are likely to be of great importance not only in the investigation of the language of mentally defective individuals but also in the study of the language of those suffering from defects in their structural functions.

The development of the capacity to use language to refer to the past and to the future has been studied by Lewis (1937). He has shown that this capacity appears as the resultant of the child's own needs and of the references made to him by adults of the past and future. Capacity to make reference to the past appears at age 18 to 24 months and is followed shortly thereafter by capacity to refer to the future. The relationship which this has to the function of memory is not yet clear.

Language and Memory. It has been known for some time that the length of the memory span is correlated with ability to use language. Robbins (1932) has reported that reduction in the memory span, as tested by means of the ordinary Stanford digit test, was present in a series of children suffering from dyslalia and from delay in the onset of speech. West, Kennedy and Carr (1937) have reported that the extent of the memory span is of importance not only in regard to the time of onset of speech but also in regard to the speed at which the function of language matures.

A detailed investigation of the feasibility of constructing an auditory memory span test has been carried out by Anderson (1938) who has found that if such a test is based upon the use of vowel sounds it is possible to demonstrate that there is a partial dependence of the ability to use language upon the extent of the memory span. It is clear that there are possible relationships between the use of language by the aged and the extent of their memory span. This field has not yet been explored.

Language and Intelligence. The problem of the relationship of the commencement of the use of language and the intelligence of the individual has received a considerable amount of attention. While conventional belief affirms close correlation between these two phenomena, practical experience demonstrates that in many instances a late development in the use of language is perfectly compatible with a good intellectual level. Hence it is not surprising to see that Abt, Adler and Bartelme (1929) found in a study of 1,000 children that the coefficient of correlation between intelligence quotient and age of speech onset was -0.41 ± 0.03 in boys and -0.39 ± 0.03 in girls. Actually this correlation was very little higher than that which was found to exist between age of onset of walking and the intelligence rating: -0.36 ± 0.03 for boys and -0.37 ± 0.03 for girls. It is commonly asserted that the scores on vocabulary test items in the ordinary intelligence test instruments correlate more highly within the total score than do the scores on any other items. It has frequently been shown, however, that at least in the case of young children the ability to use language is considerably greater in the children coming from homes in which the parents are well educated than it is when children come from homes in which the parents themselves have a limited capacity to use language.

Language and Mood. The amount of work which has been done in this field is still limited though, clearly, simple observation would suggest that important correlations between the mood of the individual and his use of language are probably present. This correlation has been investigated by Skinner (1935) but with reference to the pitch and force of vocal tones during moods of happiness and sadness. He attempted to evoke these moods by having his subject listen to appropriate music. It was found that when a mood of happiness was established, as reported by the subject, the pitch of the voice rose appreciably above that of the ordinary tones. The reverse was not, however, true; the vocal pitch of those who reported a feeling of sadness did not differ from that which they normally used. The force of the vocal tones was increased when happiness was the dominant mood and was decreased below normal when sadness was reported. A somewhat similar study has been carried out by Fairbanks and Pronovost (1939) with reference to both mood and emotional reactions. These findings are of interest in connection with the studies upon language in the pathological mood reactions by Newman and Mather (1938) which will be considered later in this chapter.

Reference was made earlier to the concept of language as an expression of the activity of the total organism. The amount of work which has been done upon this concept is limited, but two series of data deserve consideration. The first consists of observations to the effect that the presence of bilingualism may result in the development of such personality traits as indecision, apparent rather than real dullness and slowness of grasp. This is particularly likely to be the case when the child tends to think in one language and express himself in another (Scripture and Glassbury, 1926).

Stuttering. The second series of observations is to the effect that a disorder such as stuttering, which at first sight may appear to be limited to the use of language, is often more profitably regarded as an involvement of the total organism which manifests itself most apparently in the function of language.

This viewpoint is not well supported by experimental data. The claims put forward by its proponents are based largely upon case studies which have demonstrated that factors making for insecurity, tension and conflict generally were to be found in the patient's background (Blanton, 1929, 1931). The direct causal relationship of these factors has not been adequately demonstrated. Moreover, while it has often been shown that other abnormal behavioral reactions were present simultaneously in the stutterer it has not been possible to demonstrate how far they were a reaction to the stuttering, how far they were simply coincidental and how far they and the stuttering were related.

A second series of concepts concerning stuttering consists of postulates stating that this condition represents the effects of incomplete uni-hemispheric dominance. It is claimed that, at least in the case of certain stutterers, it can be shown that they were originally left-handed individuals who were forced to become right-handed. Orton and Travis (1929) have shown that on requesting non-stuttering right-handed individuals to undertake simultaneous movements of both hands action currents appear first in the nerves of the right arm in the great majority of cases; in the case of stuttering individuals who were originally left-handed but had been taught to use their right hands the action currents appear in the nerves of the left arm first in the greater number of cases. Travis has developed this concept further and reports that stuttering may follow upon shifting the individual from normal to mirror writing. Travis (1928) has also shown that normal right-handed individuals can carry out mirror tracing much more easily with their right hand than with their left while the reverse is true of stutterers who are right-handed. More extended studies (Orton, 1937) have shown that technical difficulties render it hard to place reliance upon the action current method of detecting lack of hemispheric dominance.

A third body of data related to stuttering consists in a series of physiological and biochemical studies which have not yet been coordinated into any significant pattern. Reference is made in the section on the relationship between pH and behavior to the findings of Starr (1922) with respect to a shift toward the acid side which he considers to be present in stuttering individuals. Kopp (1934) has reported that there is a higher total serum calcium in the blood of stutterers than is found in normal individuals. The inorganic phosphate is also higher, while the potassium, total protein, albumin and globulin content of the blood are lower. There is some evidence on behalf of vasomotor instability in stutterers (Fletcher, 1928) and fairly reliable evidence to the effect that the respiratory rhythm is disturbed (Fossler, 1930). It is quite unclear, however, how far these last two findings are to be ascribed to the stuttering or to the personality deviations which may accompany or arise as consequences of the stuttering.

Aphasia. It has naturally been almost impossible to carry out experimental work upon this procedure since this would involve the experimental destruction of areas of brain tissue. While certain aspects of the aphasia problem such as the non-language components of sensory aphasia can be studied in animals, this is clearly impossible with respect to such syndromes as alexia, agraphia and word deafness. Our information in this field has had to be gathered from observation of patients in whom pathological brain lesions have produced these conditions in varying degrees of purity. The general outlines of the data derived from these studies are considered in the chapter upon structural functions.

"*Speech Inscriptions.*" Scripture has carried out over a considerable number of years studies of the pattern made by the expired air during speech. Recordings have been made by having the subject talk into a mouthpiece which is connected with a marker impinging upon a smoked drum. This procedure has found its maximum utility in neurological conditions (Scripture, 1930) but it has been claimed that it is possible to detect very early changes in the speech of general paralytics by this means (Scripture, 1917, 1923). The distinguishing characteristic in these patients was an irregularity in the force of the expiratory puffs of air. It was also found that the speech of epileptic patients could be distinguished by this technique on the basis of a lack of the melodic rhythm which is found in normal voices. This lack of melody was not, however, a constant phenomenon since if a mood of cheerfulness and vivacity was provoked this symptom would disappear, though only temporarily (Scripture, 1926). A further development in this field consists in the study of sound tracks of the voice as recorded by the ordinary sound film (Janvrin and Worster-Drought, 1932). It is claimed for both methods that it is possible to detect changes in the voice by these means in the early stages of disorder before the unaided ear can pick them up.

Manic Depressive Reaction. There is a considerable body of clinical material available which deals with the use of language in the manic depressive psychosis. There is general agreement that there is a slowing of speech and a limitation of total output in the depressive phase, while an increased and rapid output which may be accompanied by rhyming and other forms of superficial verbal connection is found in the manic phase.

Newman and Mather (1938) have carried out a more precise study of both phases. They find that there are lax articulatory movements together with a narrow pitch range in the depressions, while vigorous articulatory movements and a wide pitch range are found in the manic reactions. The response is limited in the depressions and there is little initiation of response while the opposite is true of the manic patients.

Schizophrenia. The disturbances of the use of language in schizophrenia are numerous; by no means all of them have been subjected to experimental investigation. Among the more common disturbances are the reduction in output of speech which is found in catatonic stupors and the increased output which may be found in paranoid and catatonic reactions. Transitory inhibition of speech has often been reported, as have varying degrees of incoherence — verbigeration, word salad. The formation of new words and the occasional construction of a new language (Baird, 1928) have also been recorded.

One of the more striking and common phenomena of schizophrenic speech is the unusual way in which words may be employed and the unusual associations which may be established between concepts. This has been considered in the section on thinking (Cameron[a, b], 1938). White (1926) who considered that schizophrenia was a regressive psychosis, a view which has not received much subsequent support, suggested that our difficulty in understanding the meaning of schizophrenic speech may be due to his carrying on his thinking and his language function on a lower level of abstraction. White also proposed that certain rhythmic disorders of schizophrenic speech such as echolalia, lalling and verbigeration might be best studied from the point of view of oral pleasure.

Echolalia, which was referred to earlier as being occasionally found in the speech of schizophrenic patients, is found in several other types of reaction — organic brain syndrome, advanced epilepsy and in conditions in which the oxidation rate of the brain is reduced as in hypoglycemia or partial anoxia. Schneider (1938) has attempted to bring together echolalia, echopraxia, grasping and sucking movements. He considers that they are found in two main categories of abnormal behavior — first, where there is a disturbance of cerebral integration such as he considers to be present in certain psychotic conditions, among them being schizophrenia, and secondly, where the neural pathways are interfered with as in cerebral vascular disease.

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CHAPTER VII

PERSONALITY FUNCTIONS

The term personality is very unsatisfactory. It suffers from several serious defects. First, it has had a long history during which it has acquired an extensive series of meanings and secondly, it is used in lay conversation as well as in technical discussions. Indeed were it not necessary to have some term which expresses the totality of the activity of the higher level functions of the human organism considerable gain might follow its deletion from our technical vocabulary.

It is clear that a systematic classification of the activities and functions of the higher levels of the organism ought to include those which we have described under the function of memory and of intelligence. In practice, however, this is not done, possibly because these two activities were brought under experimental investigation long before the present interest in the unitary action of higher level activities arose.

If the difficulties in reducing the function of memory and intelligence to experimental terms were great, those encountered by workers endeavoring to reduce the remaining aspects of higher level functioning to workable concepts have been more than considerable. Few of the concepts thus far evolved are able to withstand critical analysis, particularly if that analysis is of a statistical nature. At best it can be said that they represent attempts to formulate for more careful assay beliefs which have long been held regarding human behavior. As a consequence of this procedure certain errors which are an integral part of our day to day thinking about human behavior have become incorporated even into those social tools which we are now forging for the scientific study of human behavior.

Conventional beliefs regarding human behavior have quite failed to emphasize that the organism is in a constant state of change. The conventional viewpoint demands continuing identity. It enhances the feeling of security. Without it the current doctrines of moral responsibility would be impossible. Strictly speaking, the organism changes its identity from moment to moment; practically speaking, it retains sufficient identity to permit recognition over long periods of time.

Because of the bias toward continuity of identity which exists in our everyday thinking, the actual fact of continuing change at the higher level functions is not clearly grasped and it is the general rule to find statements being made concerning the degree of introversion, or emotional instability or of sociability of the individual upon the basis of single tests or interviews.

A further difficulty is presented by the fact that while we can describe the function of part-activities, *e.g.*, conditioning, we cannot describe at all accurately the fundamental function of the total organism. This fact can be brought out more clearly by a simple illustration. If we were not aware of the fundamental function of the automobile we might well be greatly puzzled by the reason for the cooling system, the various containers for oil and water, the apparatus for making sounds and the presence of air under pressure in the tires. As soon as we are aware, however, that the fundamental function of the automobile is transportation the relation of these parts to each other and their integration in the whole becomes considerably clearer. Furthermore, we are able to assess the seriousness of defects in one part in terms of the effects which it will have upon the fundamental function of the whole automobile.

We are not able to do this in the case of the human organism.

It is true that we can describe with some detail certain of the part-functions of the organism, *e.g.*, the function of conditioning, or of learning, but we have as yet arrived at no universally or even widely satisfactory formulation of the fundamental function of the human organism. If we could, it would be much easier to break down the static concepts represented by such terms as extroversion, shyness and depression and express the facts which they contain in more dynamic concepts based upon their significance with relation to the fundamental function.

If we could say, for example, that the fundamental function of the organism was to increase its control over the environment, we could use some of the data at present incorporated in the concepts of introversion and extroversion to set up further postulates based on the question of how far this central tendency was expedited or retarded by the activities represented by the data.

In spite of these difficulties a great deal of work has been done upon the development of means to assess the higher level functions. The impetus for this work has come from several sources. It was early recognized that while the intelligence scores were fairly highly correlated with the degree of success in school (*see* chapter on Learning Function) they were poorly correlated with subsequent success in life. Further study of this fact has shown that, apart from purely fortuitous circumstances such as local opportunity or influence of friends, success in life is dependent upon the presence of certain personality functions in addition to the function of learning. These necessary personality functions have naturally attracted considerable attention. The reports of Terman (1939, 1940) upon subsequent studies of exceptionally able children, carried out 15 to 17 years after they had been originally studied, serve to demonstrate this problem in clear outline. He found that, although recheck of the intelligence scores showed that his original group was still homogeneous in this regard, considerable divergence in the success attained by his subjects was discernible. Success was assessed in part on an economic, in part on a prestige, basis. Among the factors responsible for this was the sex of the individual. It is not clear what aspect of sexual differentiation was responsible. Clearly one must consider seriously the fact that our culture still accords to women economic possibilities which are limited compared with those open to men. A second factor which may have played a part was the amount of pressure to succeed. This appears to have been definitely operative in the case of Jewish children. Still other factors which require further investigation are the social attitudes of the family from which the child came, and the degree of emotional stability shown by the individual. Furthermore, the growth of recognition of the importance of the "human factor" in industry and business has resulted in a demand for means of estimating such attributes as emotional stability, tendency to neuroticism and degree of extroversion. Finally there has been some continuation of study directed toward still valid problems arising from an older more theoretic approach. This is well exemplified by the work which is still being carried out in the general field of perseveration.

As a consequence of the fundamental difficulties which lie in the way of formulating working concepts in this field and because of the purposes for which knowledge of the higher level functions is sought it is not surprising that considerable confusion still persists.

There is no general agreement as to generic quite apart from the particular designation of personality functions. Certain workers refer to personality traits, others to social attitudes, and some to personality factors. No reliable method yet exists which permits us to differentiate between those aspects of personality functions which have been inherited and those aspects which represent cultural accretions or arise from strictly individual experiences. The probability that some aspects of personality functions may be inherited is suggested by the work which has been done upon the inheritance of the learning function.

Introversion-Extroversion. The concepts of introversion and extroversion well exemplify what has been said. Although these designations are of recent origin the ideas which they embody have had a considerable historical development. It is in comparatively recent times, however, that attempts have been made to remove these from the realms of the purely intuitional and observational and to put them upon a quantitative objective basis.

Spearman (1927) sought to trace the modern development of these two personality concepts from the discoveries of Müller and Pilzecher (1900) regarding perseveration and the views of Gross (1902) as to secondary functions. Müller and Pilzecher originally defined perseveration as the tendency which ideas have to return to consciousness and Spearman pointed out the difficulty which individuals possessing a strong tendency toward perseveration would experience in situations requiring a rapid change of attention. Gross, in developing his concept of secondary function, laid stress on what in the light of our increased knowledge of perseveration we are more inclined to consider as constituting that concept. Indeed he quite precisely defined secondary function as the tendency of an activity to persist after it has disappeared from consciousness.

Spearman believes that these concepts of perseveration and secondary function are supplementary and together are responsible for the concept that in some persons mental processes persist for a long time after the cessation of the stimulus which gave rise to them, while in those individuals in whom perseveration and secondary function are minimal the reverse is the case. It is possible to see a kinship between the first case and the functioning of the introvert and between the second and the extrovert. This concept has been disputed by Pinard (1932) who gave a series of perseveration tests and a questionnaire designed to bring out introversion-extroversion characteristics to a group of 144 subjects. No significant correlation could be found. However, it must be borne in mind that the questionnaire method is most unreliable.

Jung (1923) gave these types their present names and elaborated them considerably by according recognition to the influence of training and experience upon the original disposition of the individual with reference to introversion or extroversion.

In spite of the extensive work which has been done in developing these concepts, they have paid meager dividends in the form of useful information concerning higher level functioning. Attempts to utilize them for research purposes have, in the majority of instances, suffered shipwreck upon the fact that no adequate means has been devised to measure introversion and extroversion. The greater number of procedures are set up in the form of questionnaires, most of which are quite unable to avoid the so-called halo effect. By this is meant that it is very difficult to devise a questionnaire in such a way that certain answers will not appear socially acceptable and others socially unacceptable.

Furthermore, it is clear that different workers attempt to distinguish between introversion and extroversion on several different bases. Gilliland (1934) groups these as (1) differentiation on the basis of interest, (2) on the basis of adaptation to social environment, (3) on the basis of overt and implicit behavior and (4) on the basis of the activity of the autonomic and central nervous systems. Comparison of the scores of 172 students upon the Bernreuter, Colgate, Marston and Northwestern test questionnaires, which are claimed to measure introversion-extroversion, showed that the degree of correlation was so low as to be almost insignificant.

These difficulties and divergences of viewpoint are so considerable that in a recent survey of test items, in which a large number of experienced workers were asked to participate, little or no agreement could be obtained as to which items could be relied upon to denote introversion and which extroversion (Collier and Emch, 1938).

In spite of this serious defect, attempts have been made to utilize these concepts as research tools in attacks upon several major problems. One of the most provocative of these is the question whether the major psychoses are associated with introverted or extroverted prepsychotic personality types.

It is widely stated in the clinical literature that the prepsychotic personality of the schizophrenic is predominantly that of the introvert and that the prepsychotic personality of the manic depressive patient is characterized by extroversion. An extension of this statement is the assertion that the manic depressive patient represents extreme extroversion while the schizophrenic patient is an example of extreme introversion. The factual basis upon which this stands is limited and indeed there is some evidence that the theoretical support which it is said to find in Jung's original work is due in part to misinterpretation (Collier and Emch, 1938).

Few further data of a reliable nature have been furnished by experimental means since the greater part of the work has been carried out through the questionnaire method. Gilliland and Morgan (1931) found that an elaboration of the Neymann-Kohlstedt test (1929, 1930) affords a good separation of a group of manic depressive and schizophrenic patients. Root and Root (1932) found that, while on applying a test of introversion-extroversion to a group of 1,000 normal individuals, the results obtained fell into a curve of normal distribution, application of the same test to a group of schizophrenic and manic depressive patients resulted in a fairly clear separation of the patients upon the basis of their disorders. The results obtained by Campbell (1929), while tending in the same direction, were obtained from the study of so small a clinical group as to raise questions regarding their validity. It has been suggested by McDougall (1929) that introversion and extroversion are intimately related to the reactivity of the central nervous system. He has further suggested that the speed of fluctuation of the Necker cube should be increased in the introverted and decreased in the extroverted group. Hunt and Guilford (1933) have found that the fluctuation rate of manic depressive patients is from four to six times as slow as that of schizophrenic patients. The rate for the latter, however, was the same as in the normal control group. Cameron (1936) reported that, while the fluctuation rate in depressive patients was low, it rose to normal ranges as recovery progressed. It seems likely that the general slowing which is characteristic of the depressions may well be responsible for the slowing of the fluctuation of the Necker cube in this situation. It is also noteworthy that the reaction time is slowed not only in the depressive but also in the manic phase. (*See* section on mood reactions.)

As our knowledge of the earliest symptoms, particularly of schizophrenia, progresses (Cameron[a, b], 1938), it seems increasingly probable that the belief that an introverted personality was particularly prone to schizophrenia rested at least in part upon a failure to realize how long these very early symptoms of loss of interest might persist before a final social breakdown occurred.

This uncertainty regarding the relationship between introversion or extroversion and the manic depressive or schizophrenic psychoses has rendered of less immediate importance the attempts which have been made to clarify the condition under which introversion or extroversion might be modified. A certain amount of experimental work has been done by McDougall (1929) upon the effects of various drugs. He has reported that alcohol, ether and chloroform tend to promote extroversion, while strychnine, morphia, tea and coffee have the opposite effect.

In spite of the failure of these concepts to yield data of any real value, the basic facts upon which these concepts were founded remain. It is a matter of common experience that there are individuals who, over long periods of time, are withdrawn, sensitive and inhibited, and that there are others who are active, friendly and not at all prone to feel slights. It seems highly probable that these differences are due to factors which, if they could be adequately conceptualized, might give us considerable control over behavior. Some light may be thrown on the situation by the observations regarding the different types of reaction which may be elicited in the excitatory and in the inhibitory dog by the same type of etiological agent based upon conditioned reflex principles (Pavlov, 1928). There is also quite a strong possibility that introversion-extroversion is not a unitary trait, but may be composed of several factors (Murphy, Murphy and Newcomb, 1937). Clearly, if this is the case, isolation of these factors might enable us to obtain much more precise measurement than has been possible thus far.

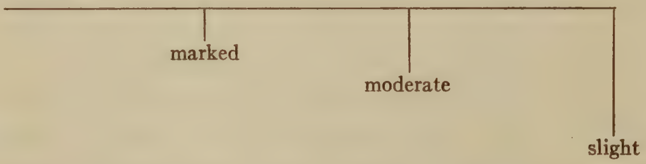
Neurotic Inventory. A considerable number of questionnaires has been devised which have as their purpose the detection of neurotic tendencies. However, no adequate means has been devised to rid these test instruments of their halo effect. Attempts have been made to conceal which answer is the more socially acceptable; suggestions have been made that the individual should record the traits that he would wish to have rather than those which he considers he already possesses, and efforts have been made to arrive at some measure of the halo effect by comparing signed and unsigned questionnaire ratings. Apart from the great difficulties presented by the fact that individuals will always tend to assign to themselves the more socially acceptable description and the fact that there is no reason to consider that the individual is the best judge of what capacities he does possess, a still greater difficulty exists in the fact that there is little or no agreement as to what is neurotic.

Indeed there is considerable difficulty in differentiating between test items which tend to elicit introversion and those which elicit psychoneurotic traits (Thurstone and Thurstone, 1930). Bernreuter (1931, 1933[a, b]) found that there was a correlation of + 0.94 between that portion of his personality inventory which tested neurotic traits and that portion which tested introversion. To a lesser extent this was also true of the correlation between neuroticism and ascendance.

The original work upon the devising of a means to estimate the degree of neurotic instability was initiated under the pressure of the First World War. There was a considerable need for some instrument which would permit the estimation of the behavioral stability of enlisted men.

The test took the questionnaire form and consisted of about 200 questions based on material found in McCurdy's War Neurosis and other similar publications. The test was given to a group of Columbia undergraduates and subsequently checked upon a group of 2,000 drafted men. The test was revised and reduced to one of 116 questions. This test has been variously known as the Woodworth Psychoneurotic Inventory and the Woodworth Personal Data Sheet. Numerous studies have been carried out with this instrument. Matthews (1923) has worked with the test in emotional stability in children; Slawson (1925–1926) used the test on a large group of delinquent boys and compared his findings with those of Matthews on boys of the unselected group. Garrett and Schneck (1928) carried out a study on a group of war psychoneurotics and compared them with a freshman group from Columbia University. Papurt (1930–1931) tried out the test on a group of patients admitted to the psychopathic ward of the Cleveland City Hospital, utilizing as controls the findings of Franz whom he quotes to the effect that the average, normal, white individual answers about ten questions pathologically while abnormals answer 30 to 40 unfavorably. He further states that an individual who answers twenty wrongly should be suspected of instability while anyone answering thirty or more unfavorably is open to grave suspicions. The technique of administration is simple, the answers being framed in such a way that they can be answered by *yes* or *no*. This method of testing has all the faults of its kind. Though it is to be considered with the objective tests, there can be no doubt that a good deal of subjectivism enters into it in so far as the subject is asked to pass judgment upon himself every time that he answers one of the questions. A further difficulty that has been pointed out is that the same question may have slightly different meanings for different persons.

In order to overcome the difficulty that some subjects experience in returning a decided *yes* or *no* to the questions of this and similar tests, a scale form of answer has been devised, the subject placing a mark on the line at a distance in relation to one of the descriptive terms which he feels most adequately conveys his judgment.



As yet few adequate reliability checks have been made on the test, at any rate, as to its stability on recheck. The most usual method of scoring is to count the pathological answers.

Matthews has constructed a revised list of seventy questions and has applied this to a large group of children ranging from 10 to 18 years of age. She found that the score varied inversely as the age, and has provided a fair number of norms at the age levels within the age indicated. Two disadvantages of the Matthews revision are that the sex questions have been eliminated from the original version and there are no questions which deal with the more aggressive traits.

Slawson carried out an extensive investigation on 879 delinquent boys, using the Matthews revision. His purpose was to evaluate, as far as possible, the part which emotional instability played in the production of delinquency. He found that the delinquent group showed definitely higher scores than did the boys of Matthews' unselected group. Incidentally he found, as did Matthews, that the scores bore an inverse ratio to the age of the subject. He finds, moreover, that the social status and the nationality of the subject have little bearing on his score. From these facts he considers that a poor score is evidence of defective emotional patterns that are constitutional and in the production of which the environment has little share.

It would seem at least a reasonable hypothesis to consider that many of the psychoneurotic responses, as they have been termed, are actually responses which, taken by and large, are normal for various levels of organization of the personality. As the individual grows older the personality evolves also as to its degree of organization, and the "psychoneurotic" responses become fewer. On this hypothesis the delinquent boys would be more accurately looked upon as individuals whose personalities were integrated at a level immature for their chronological age. There is already evidence from other sources, such as the study of psychopathic personalities, that delinquency and poor personality organization are closely related.

Slawson has further divided this questionnaire into groups of questions dealing with various aspects of the personality, such as impulsive tendencies, morbid states of joy and anger, and conflicts with the environment. On this basis it is possible to make a more detailed analysis of the individual subject's responses.

Garrett and Schneck compared the results obtained from applying the Woodworth Psychoneurotic Inventory to 103 Columbia College freshmen with those obtained by the same test on 256 cases of psychoneurotic upset among soldiers. Using the gross score they were not able to make an adequate differentiation between the two groups. On revising the list and utilizing only those tests which were most potent, they were able to achieve good separation of the two groups, though the freshmen group continued to answer a fair number pathologically. From this they conjectured that, since the freshmen were all making an apparently good adjustment in all spheres of their university life, possibly more than a simple accumulation of pathological trends was necessary to provoke a breakdown. They suggested that perhaps a breakdown was prevented by the fact that the students were leading a more or less sheltered life, and that possibly the pathological trends were offset by balancing interests. In other words, they suggested that the students' assets outweighed their psychological debits.

The use of an unchecked body of students as normals must be looked upon with some reserve in view of the high incidence of problems of maladjustment reported by student advisors and mental hygiene workers.

The authors also endeavored to use the test to differentiate between the various types of psychoneurosis, but without success. Their failure they attribute either to the various psychoneuroses not being hard and fast entities or to a tendency on the part of the psychoneurotic to be hypochondriacal and to lay claim to the possession of numerous symptoms actually foreign to their reaction type. Papurt has carried out the test on fifty men and fifty women admitted to the psychopathic ward of the Cleveland City Hospital. No attention was paid to the type of diagnosis, beyond that they were suffering from a form of mental disorder. There were 22 per cent of the patients who answered nine or fewer of the questions pathologically. That is to say, according to Franz's criterion of ten pathological answers, 22 per cent of the patients showed themselves to have attained to normal at least in this regard. He offers no adequate explanation of these rather disconcerting figures.

On the basis of this work, however, he suggests a revision of the original Woodworth Inventory. His changes are along five different lines. First, he simplifies the terminology; second, he cuts the number of questions from one hundred sixteen to seventy-five; third, he feels that there is a considerable number of questions which do not deal with emotional stability; fourth, there is a considerable reduplication of questions; and fifth, he adapts the questions to both sexes. The revised version has not yet been subjected to test.

Fleming and Fleming (1928–1929) compared the rating of a group of four teachers as to the "emotional balance" of a group of eighty-eight high school girls with their performance on the Woodworth Inventory (Matthews' Revision). They obtained an $r = -0.1481$. The fact that the Inventory was given two years before the rating by the teachers must seriously invalidate the results, especially in the light of Matthews' findings to the effect that the score on the Inventory has a negative correlation with age.

These tests of neuroticism have continued to give extremely varying results. In certain situations they showed a high positive correlation with the ratings of competent judges; in others they failed to demonstrate definite neurotic traits even in psychiatric patients. These imperfections have limited the neurotic inventory as a research tool. At present its chief value to psychiatry is as a means of developing contact and as a

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means whereby the individual's own rating of himself can be compared with factual material which the psychiatrist may already possess concerning him (Vernon, 1938).

Factor Analysis. Factor analysis constitutes a further attempt to reduce personality data to a form in which it can be dealt with experimentally. The first steps in the development were taken by Spearman (1927) who advanced the suggestion that the phenomena of intelligence as they were seen by the external observer were the products of two factors — *g* which denoted the native intelligence of the individual and *s* the special ability through which his intelligence was being manifested at the time. For example, *g* in a person who had a limited ability to solve mazes but a special ability in mathematics would be rated very differently depending on whether the test employed was comprised of maze solving or arithmetical problems. It is clear that a much truer picture of his actual intelligence will be gained if both forms of tests are used and it is also obvious that the greater the number of tests which we can use practically, the more the influence of good endowment or poor endowment in any one field will tend to cancel themselves out and one will thus obtain a closer and closer approximation to *g* or his native intelligence.

One further provision, however, must be made and that is that there must not be undue overlapping of the tests. To cite an extreme example, in testing the intelligence of a mathematician we must not compose our scale of one series of tests in algebra, one in arithmetic, one in geometry and a fourth in maze solving, for there is a close correlation between ability in arithmetic, geometry and algebra and consequently the special ability of our mathematician in this direction would cause his intelligence rating to be unduly high.

Somewhat intricate mathematical techniques have been devised to further the development of this field. Spearman and his pupils have announced the identification of several other factors, notably p, the perseveration factor, and w, a factor which was associated with steadiness of character. The presence of these factors, particularly p, has been worked out in several of the psychotic groups. Stephenson (1932) considered that manic patients tended to show little evidence of perseveration, while this factor was marked in the depressive patients. More recent work (Cameron, 1940) suggests that the recent memory defect of senility may in part be due to a greatly increased tendency to perseverate. He found that the tendency of his patients to perseverate was so strong that when two objects were put successively before such patients the second was often not perceived for what it was but seemed to act as a stimulus for the reactivation of the memory of the object which had immediately preceded it.

This concept of perseveration requires further investigation. It has been reported that variation in the amount of perseveration is present in many different conditions. Both Goldstein (1936[a, b]) and Harrower (1939) find that it is increased when organic lesions of the brain are present.

Ewen (1930) has investigated the motor, sensory and ideational aspects of perseveration in mental hospital epileptics. To this end he utilized the color fusion tests — a test based upon adaptation to dim lights for his sensory tests. For his motor tests he used forms of the X–Y tests and for the ideational aspect he endeavored to test the fluency of association by having the individual give, as quickly as possible, the names of as many animals as he could think of in one minute. He also had his subjects enumerate as many objects as possible from the inspection of ink blots. He found that by the use of these tests he was able to separate his ten normals without difficulty from his twenty epileptic cases.

Stephenson (1931, 1932), working with mixed psychotic groups, believes that there is evidence to substantiate Wiersma's claims to the effect that in perseveration (p) performance there is a manic depressive sequence, the manic cases tending to show little p and the depressives to show high p scores.

He was not able to corroborate Wiersma's statement to the effect that dementia is associated with decreased psychical after-effect, since he found that in those cases of schizophrenia in which dementia supervened the p scores were high.

He found also that the p score tends to vary with the clinical progress of the case, a high p score being present when the clinical condition became poor.

He also noted that the p score was subject to fluctuations in the course of a few minutes and suggested that p activity may be oscillatory in nature.

The X-Y-X' type of test most commonly used to demonstrate perseveration is by no means free of faults. These tests are based upon one of the essential aspects of perseveration, namely, that the carrying out of one activity tends to interfere with the initial performance of a second activity. X represents the first activity, Y represents the interfering activity and X' represents the first activity as carried out again under the interfering influence of the just terminated Y activity. By comparing the production of X and X', a calculation of the degree of perseveration can be achieved. Cameron and Caunt (1933) investigated the validity of this form of test and found that initial spurt regularly occurred in X, though not in X'. A further complicating factor consists in the existence of "rebound." There is a tendency for the rate of production to rebound above normal after having been temporarily depressed by perseveration. It was also found that a single test was of doubtful value. A series of immediate repetitions of the test was reported to be of value in showing the range of fluctuations of p and the direction of the change.

The technique of factor analysis has been extensively developed by numerous workers. In particular Thurstone (1934) has devised a method whereby a series of data may be investigated for multiple factors. It must be borne in mind, however, that those errors and limitations which were inherent in the data which are factorized will also appear in the factors. Thurstone (1934), for example, has applied his method of multiple factor analysis to a series of psychotic symptoms compiled by Moore. He was able to extract five factors composed of clusters of symptoms — a manic, catatonic, cognitive, hallucinatory, and depressive cluster. The fact that any experienced and observant clinician could have assembled just such symptoms under these headings is perhaps less disappointing if one bears in mind the point made above, namely, that the nature and mode of collection of the data are inevitably reflected in the type of factors extracted.

Masculinity-Femininity. It has long been assumed that the differences in social behavior which exist between the sexes are fundamental in their origin. Since the development of the intelligence tests it has been shown (Terman, 1916) that little or no difference exists in the scores obtained by the sexes on these tests. This fact, so contrary to previous popular belief, has led to enquiry as to the nature of sex differences.

The progress which has been made in this field is still small and its applications to the problems of abnormal behavior are limited even with reference to homosexuality. Goodenough (1927) states that the studies in this field show great inconsistency of finding because of the difficulty in separating the influence of biological and sociological factors in the production of sex behavior. Allport and Vernon (1931) have studied the values accorded by the sexes to various aspects of social life. They found that women accorded the highest ratings to the esthetic, the social and the religious, while men valued more highly the theoretical, economic and political. Mead (1935), from her studies of primitive communities, has raised still further questions as to how far sex differences in behavior may be cultural in origin rather than constitutional. She has shown that in certain cultures the sex differences in behavior which we customarily accept as valid may be reversed. She describes communities in New Guinea where the women are active, aggressive and are occupied in such pursuits as hunting and fishing while the men are timid, dependent and are more concerned with home pursuits. The most extensive work in the field of sex differences in behavior has been carried out by Terman and Miles (1936). They have devised a questionnaire type of test on the basis of which they seek to differentiate male and female behavior. Comparisons of the results of the test with simple ratings made by various observers show that there is great variation between observers and to a lesser extent between the consensus of observers and the results of the test.

Terman and Miles consider that these differences arise in part from the fact that it is extremely difficult for the observer to differentiate between the actual behavioral tendencies of the individual and the attempts of the latter to achieve social conformity. They point out that the homosexual individual can much more readily conceal his tendencies than the intellectually retarded individual can hide the limitations of his capacity. Further factors lie in the observers themselves. Miles and Terman showed, for example, that mature females tended to overestimate the masculinity of girls in their teens, while mature male observers detected their femininity more adequately. Similarly, mature male observers tended to underestimate the masculinity of male adolescents.

The *M–F* test, devised by Terman and Miles, does not permit an estimation of homosexuality if one understands by that term the frank appearance of inverted activity. These workers claim, however, that it does permit measurement of the degree of inversion of the sex temperament. They suggest that its value in this field may consist in assisting in the study of the subsequent development of masculine scoring girls and feminine scoring boys. From such studies valuable information concerning the evolution of frank homosexual tendencies might be obtained.

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CHAPTER VIII

FACILITATIVE FUNCTIONS

There are certain higher level activities of the organism which, while not resulting in the accomplishment of a specific pattern such as is the case with learning or memorizing, tend to promote or facilitate whatever activity the organism is engaged upon. These activities comprise the reactions usually described under tension, emotion and mood. It is questionable how far these should be considered separately. However, current usage has tended to focus attention upon the dissimilarities which exist in these activities rather than upon the evidence which suggests that they may represent varying aspects of the same activity. It must, of course, be emphasized that while these functions are under ordinary circumstances facilitative, the inhibiting action, which they normally exert upon those activities which interfere with the main activity that is being facilitated, may become greatly intensified and tend to interfere with the main activity itself.

Tension. In the light of our present knowledge the most adequate definition of tension is that it is a state of psychobiological preparedness. It is a reaction which apparently accompanies all higher level functioning in the human organism. The participation of the lower functional levels in the reaction has evidently been better described and measured than that of the high levels. In general there is an increase in muscular tonus; tendon reflexes are increased. In the more marked forms there is an increased excitability of the cardiac and respiratory apparatus, and tremor. The blood pressure may be definitely elevated. The subject may report a feeling of alertness and well-being, and in the more severe forms actual feelings of tension and apprehension may be recorded.

There is a considerable amount of experimental evidence to suggest that the relationship between tension and higher level functioning follows a parabolic curve (Stauffacher, 1937). When tension is greatly reduced or absent, the higher functions become less active. Jacobsen (1938) has reported that only a small minority of subjects trained in relaxation were able to produce images on request without at the same time showing neural discharges to the muscles appropriate to the images evoked. For example, in the great majority of instances it was impossible to elicit an image of throwing a ball with the right arm unless at the same time neural discharges to the muscles of that arm were produced. Similarly it has been shown that the number of emotional responses to the presentation of pictures is reduced if the subjects had been trained to relax during the procedure (Cason *et al.*, 1938).

As tension increases from this low point, the activity of the higher functions also increases; learning tests are more rapidly mastered, errors are reduced and in general the efficiency of the organism is increased. Beyond this point further increase in tension begins to interfere with the adequacy of the reactions of the organism. The precise mechanism of interference is not clear but in general it may be said that as tension increases the attention of the individual tends to be focused on topics of concern to which he continually returns. These topics may be direct causes of the increased tension or related only through a process of symbolization. Under stress of great and continued tension, thinking becomes increasingly directed toward the objects of concern. Anything which tends to compete with the prevailing preoccupation is inhibited in varying degree. In this way perceptions which are at variance with the topics of concern are either shut out or misinterpreted to the point where they fall in line. In the case of extreme tension the picture becomes that of agitated depression. In other instances the growing tension may show itself in brief bursts of acute anxiety or panic states, the patient between attacks maintaining a high degree of tension.

Since tension is a sweeping type of reaction it has been possible to find several indices by which it may be measured. Jacobson's (1938) excellent contributions to the field have been based on the use of the neuromuscular apparatus as an index of tension. The neural discharges to muscle groups have been recorded and it has been shown that in complete relaxation the volleys which can be picked up during movement or tonic contraction of the muscle disappear. By utilizing this concept it is possible to study varying degrees of tension and relaxation.

The blood pressure is frequently used as an indicator. In the case of severe or long-continued hypertension it is necessary to determine how far the increased level may be due to factors other than tension. Much information may be obtained on this point by running twenty-four-hour blood pressures. It has been claimed that in the individual who is not suffering from structural hypertension the ordinary waking systolic pressure is about 20 mm. of mercury higher than the basal night pressure. This serves, it is stated, to differentiate hypertension due to kidney damage or vascular change from that due to emotion. Actually this is not the case (Cameron, 1940). The point of greatest differential value appears to be the fact that there is greater instability of pressure in the emotional hypertensive group than in the structural hypertensives. Further information as to the reactivity of the vessels may be obtained by injecting a standard amount of histamine (0.000021 mg. per Kg. of body weight) intravenously and following the rise of the spinal fluid pressure (Cameron and Rosen, 1940). Histamine produces marked dilatation of the arterioles and produces a transient paralysis of the capillaries. For this reason there is a rapid increase in the blood content of the cranium, and the spinal fluid pressure is raised to a point proportionate to the amount of dilatation of the vessels. In patients in whom loss of dilatability has occurred there is a considerable reduction in the rise of the spinal fluid pressure, the average reduction being about 30 per cent.

From blood pressure observations upon patients suffering from tension it may be said tentatively that elevations of 20 to 30 mm. of mercury above the daily working pressure may be tolerated over periods of days and weeks. Elevations of 40 to 60 mm. of mercury due to psychological factors can be tolerated for brief periods, *e.g.*, during an anxiety attack, but the degree of tension sufficient to produce such elevations cannot be sustained over periods of days without beginning to produce that disruption of higher level functioning which has been described earlier in this chapter.

The pulse rate has been studied as an indication of tension. Even such an implicit activity as counting to oneself has been found to produce an increase in pulse rate as recorded by a form of electrocardiograph (Hoagland, Cameron, Rubin, 1938). It seems probable, however, that the pulse rate cannot be taken as an unequivocal guide. Following upon any stimulus which produces a temporary marked increase in tension it is clear that the products of the accelerated metabolic rate which is occasioned by the increased tension have to be eliminated and, since the blood stream is the vehicle in which these must be conveyed, it is clear that the pulse rate reflects a double function.

The skin resistance has also been employed as an indication. Landis and Hunt (1935) have found that deviations are more closely related to feelings of tension and startle than to any other conscious state reported by the subject.

In every attempt to assess tension by utilizing an index such as that described above, it is necessary to bear in mind that tension frequently manifests itself in different degree in the various functions of the same organism. It is a matter of regular experience that a considerable amount of tension may be present as shown by hyperreflexia, sweating and a fast pulse rate, even though the blood pressure may not be elevated.

While some progress has been made in the direction of recording and measuring tension, efforts are also being made to evolve some standard means of evoking tension. The psychologists have worked with procedures which involved putting the musculature into a state of maintained tonic contraction, *e.g.*, by having the subject exert a constant pull or pressure (Stauffacher, 1937). Attempts have also been made to produce some transitory increase in tension by presentation of verbal or visual stimuli. Clearly it is exceedingly difficult to conceive that any one such stimulus has the same meaning for a series of subjects.

To a certain extent the same criticism can be offered in regard to the use of the cold pressor test. It has been frequently demonstrated that patients suffering from tension and anxiety states show, during the test, a rise in blood pressure and pulse rate which is considerably greater than the normal (White and Gildea, 1937). It is necessary that this test should be used in the production of tension only after careful consideration has been directed to the mechanisms which it calls into action. It is clear that at least on theoretical grounds we may postulate that a marked response to this test may be anticipated not only in patients who are showing increased tension but also in patients in whom excessive discharges of adrenalin are easily produced.

Closely allied to these attempts to study the experimental production of tension is the work which has been done upon the effects of interruption of activities (Ovsiankina, 1928). It was found that, if an activity is interrupted while still incomplete, the subject tends, upon the termination of the interruption, to return and finish the first task. In other words, there is a tendency toward the discharge of the tension system set up by the interrupted activity. Little attempt has been made to investigate such tension systems in any save normal individuals. However, Ovsiankina (1937) has reported that persons showing a schizophrenic reaction apparently have difficulty in establishing such systems. Her subjects showed a definitely diminished tendency to return to uncompleted tasks. It is of considerable interest from the clinical point of view to note that such tension systems can be discharged by the completion of a substitute activity instead of the original (Lissner, 1933).

While ample evidence exists from the observational side to demonstrate that one of the major causes of tension is conflict, this has hitherto proved most difficult to reduce to experimental terms, so that a systematic description of the mode of tension production by this means is lacking.

The control of tension can be considered in terms of its production and of its elimination. In this field Jacobson's (1938) work upon the control of the production of tension by means of techniques of relaxation is outstanding. Since it is reported that such procedures have been successful in those situations in which the primary cause of the tension was clearly the existence of a conflict situation, one must conclude that the muscular hypertonus set up by the conflict situation tends in turn to accumulate tension. Something in the nature of a circular action is set up. The interruption of this by means of an elimination of the muscular hypertonus causes a breakdown in the system of tension production.

The matter of discharge of tension is still most obscure. Clearly in daily life we make considerable use of substitute activities in a way similar to that described by Lissner (1933), but the problems in this field are barely defined, much less understood.

Emotional Reaction. By this is understood a reaction which comprises extensive involvement of the whole functional scale. There are changes in the electrical activity of the skin, increase in the blood sugar level, changes in the brain wave pattern, alterations in the posture of the organism, and changes in such higher level functioning as learning and remembering and more particularly in thinking. In the simpler organisms these changes tend to be modified only in so far as they facilitate two main groups of behavior, namely, those involving fighting and those leading to flight. In the higher organisms and particularly in man the activities which are facilitated by the emotional reaction have become more diversified and one finds the emotional reaction occurring with such behavior patterns as jealousy and disappointment, as well as with fear and anger. It is clear that the emotional reaction and tension are closely related. Tension is always an accompaniment of the emotional reaction and, as pointed out in the section on tension, as the latter increases it tends to merge with anxiety and panic states which can clearly be considered emotional reactions.

The major point of difference consists in the way in which thinking is carried out in the organism which is tense and in the organism which is undergoing an emotional reaction. In the latter there is a definite tendency to show inhibition of thinking save upon certain topics of concern. These are usually the topics and situations to which the organism is reacting and which have produced the emotional reaction. In the tense organism, at all events during slight or moderate tension, there is no such limitation of thinking. The organism is simply in a state of increased psychological preparedness for eventualities in general.

The reaction which we have just outlined includes the short term responses described as startle, the more prolonged reactions such as fear and anger, and those instances when the reaction as a whole or some part of it has become exaggerated to the point where there is interference with the efficient functioning of the organism. We refer particularly to panic and anxiety states as an example of the first and to emotional hypertension and emotionally elicited gastrointestinal upsets as an example of the second. Mention was made at the beginning of the section on facilitative reactions that the facilitation is accomplished in part by inhibition of any activities of the organism which may interfere with the facilitation of the main activity. This aspect of the emotional reaction may also be emphasized to the point where effective functioning is interfered with as in hysterical amnesia and in reactions analogous to the "freezing" produced by panic in some of the lower animals.

In considering the emotional response it is important to bear in mind that the reaction is integrated by two main agencies — the autonomic with its humoral adjuvants, adrenalin and possibly cholin, and by the central nervous system. It is valuable to consider that, in the main, the first system is responsible for changes in the internal economy of the organism — the mobilization of sugar, the provision of extra supplies of O_2 by increasing the respiratory rate and decreasing the circulation time, the inhibition of alimentary activity. The second system is mainly responsible for the relations between the organism and the environment. Endeavors to manipulate the environment or to remove the organism from a threatening situation are motivated through this system. There is a certain amount of overlap — sweating which facilitates the grasping of objects in the environment is under the control of the autonomic, but in general the concept is valid and valuable from the investigative point of view.

Experimental work upon the emotional reaction has followed two main lines — elicitation and study of the emotional response with reference to one or more of its manifestations, and secondly, experimental interference with the mechanism of the emotional reaction, *e.g.*, studies of hypothalamic activity after decortication.

Several methods have been used to elicit the emotional response. The more important of these are based upon stimulation of the higher functional levels. This has been accomplished by the presentation of pictures of painful or exciting scenes (Cason and Cason, 1933), personal conversation (Whitehorn, Kaufman and Thomas, 1935), the presentation of painful topics (Hoagland, Cameron, Rubin, 1938) and the use of the word association test. The startle type of emotional response has been produced by sudden sounds (Blatz, 1925) and by sudden withdrawal of support.

In addition, advantage has been taken of naturally occurring emotional reactions such as Gildea's (1935) study of the responses of the relatives of persons injured in accidents, and the studies of individuals suffering from anxiety (Lindemann and Finesinger, 1938) and panic states (Diethelm, 1932).

Attempts have been made to elicit the emotional response for experimental purposes by means of the injection of adrenalin. First introduced by Maranon (1924), this procedure has yielded conflicting results. It seems probable that, in the majority of cases, this means may produce many of the lower level reactions associated with the emotional response but will not interfere with thinking to the point of producing the topics of concern which were referred to earlier as constituting a major difference between the tension and emotional reaction. It is of interest, however, in connection with the relationship between tension and the emotional reaction, to note that feelings of tension are commonly reported after injection of adrenalin. In a minority of cases a definite emotional response has been noted. It appears that this arises in two ways, first by the accentuation of an emotional response which is already present or by the accentuation of an emotional response which is motivated by some other stimulus during the period that the individual is under the influence of the adrenalin. Secondly, a certain number of fear or panic reactions may be elicited simply by reason of the patient's perception of the profound disturbances in his lower functional levels. The same thing may be seen in the fear which is at times elicited by the use of sodium cyanide intravenously, as a means of estimating the circulation time, or the use of amyl nitrite. In these cases the severe responses of the respiratory and cardiovascular systems respectively may suffice to produce a severe emotional reaction.

The data which have been obtained by experimental methods, based upon the various approaches referred to, will be considered with reference to the two major integrating systems. It was pointed out earlier that the emotional reaction was coordinated in respect to the internal relations of the organism mainly by the autonomic nervous system and its humoral adjuvants, adrenalin and cholin, and with respect to its external relationship mainly by the central nervous system.

The emotional activities subserved by the latter system are those of expression, posture, skeletal muscular movements associated with emotional reactions such as those facilitating fight and flight, posture and preparatory muscular tension. In this pattern of responses should also be included those which involve the higher functional levels, such as the facilitation of learning, the facilitation and the inhibition of retention and reproduction, and those which affect thinking.

Investigations concerning the facial expression of emotion have suffered until recently from failure to recognize that these may consist not only in a spontaneous expression of emotional response but also in a social expression. For this reason much of the work which has been done with posed photographs has been relatively unproductive. Certain facts concerning the manner in which the observer achieves his judgment, however, have been obtained. First, it seems probable that the judgments are based upon the expression as a whole rather than upon an assessment based upon the study of individual aspects. Arnheim (1928) found that changes in one feature of a posed photograph might result in a complete reversal of judgment. Secondly, knowledge of the stimulus and data concerning the whole reaction, rather than a simple cross section, greatly improved the accuracy of judgment. Investigation of photographs taken during moments of actual emotional stress have tended to show that apart from smiling it is difficult to show that any given emotion is accompanied by a characteristic facial expression (Landis, 1934). Even reactions so divergent from the psychological point of view as rage and fear produce facial expressions which, when photographed, are frequently confused by a series of judges. This approach to the study of the emotional reaction has had as yet little importance for the psychiatrist. It seems probable, however, that, if reliable patterns of facial response could be worked out and correlated both with the individual's report and his typed visceral response, interesting light could be thrown upon the hysterical and schizophrenic reaction. At present the fact that difficulties are being encountered in evaluating the significance both of the true emotional expression and the social expression serves still further to emphasize the unreliable nature of the report obtained from the relatives and friends of the patient as to what his earlier reactions have been.

The movements of the body occurring as part of the emotional reaction have been studied in detail with respect to the startle reaction. Strauss (1929) described a reaction to loud sounds, which was so rapid as to require the use of the high speed camera for its adequate investigation. This response which has been termed the startle reaction has been explored extensively, particularly by Hunt and Landis (1936, 1937).

The reaction consists of blinking, forward movements of the shoulders, abduction of the upper arms, closing of the hands, pronation of the lower arms, forward movements of the trunk, contraction of the abdomen and bending of the knees. The movements are usually, but not always, symmetrical and cannot be inhibited by voluntary effort. The various movements appear in a definite chronological order; those of the facial muscles appear first, being followed by the others in order of their distance from the head. Investigation of the startle reaction in a series of patients showed that the extent of the response was considerably greater in schizophrenics, especially those showing a catatonic reaction. In patients suffering from a manic-depressive reaction the response was less, though still greater than in the normal. In epileptics, on the other hand, the extent of the startle reaction was definitely reduced. This accentuated response in the case of the individual showing a schizophrenic reaction is rather unexpected in view of the general trend of findings with respect to his other activities. The general picture is one of sluggish, poorly integrated response. Work on the reaction as occurring in recent, as contrasted with chronic, schizophrenic reactions might serve to clarify the issue. For example, it has been demonstrated that, while there is a tendency to a more rapid than average reaction of the sympathetic in response to cold and the postural change in the early schizophrenic reactions, this response falls below normal in the more chronic cases.

Taylor (1935) has reported that the production of the startle response may have a prolonged deleterious effect upon the performance of individuals who are partially trained in a task. An interesting question arises as to whether an analogy exists between this observation and the fact that emotional upset occurring in senile and particularly in arteriosclerotic individuals exerts a disorganizing influence upon higher level functioning and in particular upon memory for considerable periods after the incident has apparently disappeared from consciousness.

During the emotional reaction the muscular tension is increased. The experimental procedures which have been utilized in investigating this have already been referred to in the section upon tension.

We propose to consider the changes produced at the higher level functions by the emotional reaction as being mainly integrated by the central nervous system. It is clear that changes attributable to the activity of the autonomic, such as increase in the blood sugar, adrenalin content of the blood, and increase in the rate at which oxygen is transported to the cerebral tissues, will make a definite contribution to those changes in the higher level functioning which occur. The work upon these higher level functions has been more limited than upon the lower functions. In part this can be ascribed to the difficulties encountered in measurement due to the great speed of adaptation and consequently the greater variability which these functions show.

As is the case in work on the lower functional levels, there has been difficulty in reproducing a satisfactory emotional response in the laboratory situation. It may reasonably be claimed, however, that an emotional reaction of the startle type, such as has been employed in certain investigations upon the effects of punishment on learning and retention, may serve to give some indication of the effects of a more continued emotional reaction. It is generally agreed that, if the punishment is not so severe as to be actually disruptive of the thinking of the organism, responses, such as those elicited by an electric shock, do facilitate learning. Busch (1935) considers that the effectiveness of the shocks used in the learning of a stylus maze was greater than their mere informative value. Crafts and Gilbert (1934) who studied the influence of electric shocks upon the capacity of a hundred college students to learn a maze found that both the rate of learning and the amount of retention of learning were accelerated in the group in which shocks were used.

Reference was made to the fact that under certain circumstances the inhibitory action of the emotional response might be more prominent than the facilitative. This is well exemplified in the field of memory by the fact that unpleasant events are less easily reproduced than those which are pleasant. This has been discussed in the section on the memory function.

The influence of fear upon learning is well exemplified by a report (Hammill, 1936) of apparent mental retardation in which it was found that the difficulty shown by the child in learning to read was due to the emotional response evoked by erotic meanings which had become attached to certain words. Little work has been done upon the effects of the emotional response on thinking. The reports which have appeared in recent years concerning the effects of sodium amytal and benzedrine sulphate upon delusional ideas suggests a promising field for enquiry. Likewise, although it is a matter of common experience that there is difficulty in grasping concepts to which we are averse and which arouse an emotional reaction, little actual investigative work has been done upon this.

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CHAPTER IX

FACILITATIVE FUNCTIONS (*Continued*)

Emotional Reaction. In considering that aspect of the emotional reaction which is mainly integrated through the autonomic nervous system and its adjuvants adrenalin and acetylcholin, one is at once struck with the considerably greater amount of work which has been done in this field than in the domain in which the central nervous system is the major coordinating agent. It is clear that it is simpler for us to deal with phenomena such as the cardiac and the respiratory cycle which repeat themselves within short periods of time and which show slow adaptation. Adaptation is used here in the sense that adjustment or adaptation occurs after a period of training rather than as an immediate response to increased load. On the other hand, considerable difficulty is experienced in dealing with thinking or facial expression which cannot be readily broken up into simple repetitious blocks and which are, moreover, functions which show particularly rapid adaptation and, for this reason, are especially difficult to investigate by means of present experimental methods.

Cardiac Cycle. The cardiac cycle has provided the main index for a considerable amount of work upon the emotional reaction. Its particular value consists in the fact that it shows a rapid response to a stimulus evoking an emotional reaction, the response being, for example, considerably more rapid than the blood sugar rise or even than the fall in the electrical skin resistance. Moreover, continuous registration is possible with comparatively little interference with the relationship between the patient and the environment. At this point it should be stressed that studies, in which the recording apparatus unduly confines the patient or attracts his attention, rarely yield unequivocal results.

The disadvantages which are attendant upon utilizing the cardiac cycle as an index are, first, that the cardiovascular system has a multiple function. It is not only the main transport system bringing in supplies which the tissues will require during the period of increased metabolism attendant upon the emotional reaction but, among other things, it subserves heat elimination and also the transportation of products which are to be eliminated. The fact that metabolism is increased during the emotional reaction entails an increase in the amount of waste products which have to be eliminated. Consequently, a definite function of the increased cardiac action, especially in the later part of the emotional response, is to be ascribed not simply to the support of that response but, more properly, to the scavenging function of the cardiovascular system. A second disadvantage consists in the fact that the emotional reaction evokes not only a tendency to an acceleration of the cardiac cycle but also a tendency to an elevation in the blood pressure. These tendencies are, to some extent, mutually inhibitory, a rise in blood pressure tending to slow the heart rate and, less frequently, a rise in heart rate being associated with an inhibition of blood pressure rise. From numerous observations of the reaction to the cold pressor test it appears that, while the general rule is for a rise to occur in both cardiac rate and blood pressure, a certain number of patients tend to show dominance either in the blood pressure or the cardiac rate response. The significance of this is unknown, but it indicates the desirability of considering the blood pressure and cardiac rate responses as being, to some extent, complementary and, for this reason, recording both whenever possible.

The rate of the cardiac cycle in relation to emotional situations has been extensively studied. Changes occur rapidly. Beebe-Center and Stevens (1937) report acceleration occurs in 0.54 second in cats startled by a pistol shot. The time of rise was from 0.42 second to 2.3 seconds and the duration about 2.5 seconds. In the human subject Landis and Slight (1929) have reported changes in the electrocardiogram in the average time of 0.48 second after startle. It is of interest to note, however, that, while these changes appeared regularly in the normal controls, they appeared in only two of six subjects suffering from anxiety, two of seven suffering from dementia praecox, and in none of five patients suffering from involutional melancholia. This may possibly be correlated with the findings of Whitehorn and Richter (1937) who used a modified Boas cardiotachometer to secure continuous cardiac rate records and who employed the method of ordinary conversation to evoke the emotional responses. They report that an emotional response is frequently accompanied by an unsteadiness of the heart action and that this unsteadiness, while definitely greater in their neurotic subjects than in their normal controls, was greatly reduced in their psychotic group. It is to be pointed out further that the response to a startle situation may be in the form of a slowing of the heart rate rather than an acceleration, and Darrow (1929) has advanced the suggestion that the type of response to momentary sensory stimuli and to the associative process initiated by the stimulus is different.

The first appears to be more effective in producing vasoconstriction, perspiration, and electrical skin phenomena, while the response associated with emotional thinking is more closely correlated with changes in cardiac action. It is clearly indicated, moreover, by available data, that the psychotic group reacts differently both to stimuli of the startle type and to stimuli of an ideational nature.

The development of means of continuous registration has permitted considerable advance in the study of tachycardia of emotional origin. During sleep there is a tendency for acceleration to subside, thus providing a means of differentiating between such tachycardias and those associated with organic heart disease or exophthalmic goiter. It seems probable, however, that, although the rate subsides considerably in such emotional patients, it does not fall by as much as the average 20 to 24 per cent found in normal subjects. Boas and Goldschmidt (1932) quote Vaschide as having found that, when the individual goes to sleep with the intention of awakening at a given hour, the pulse rate during this so-called attentive sleep is higher than during ordinary sleep. This clearly suggests the persistence of tension carried over from the day.

Some reports (Fleisch, 1933) have been made concerning the effects of emotional situations on the production of extrasystoles, but further electrocardiogram studies are required to clarify this problem.

Blood Pressure. The blood pressure has not been used so successfully as a means of investigating the emotional response. This is due in the first place to the lack of adequate means of continuous recording. Devices for this purpose have been worked out from time to time; but, since they are usually based on estimating the systolic pressure by occluding the artery, the consequent discomfort and possible damage to tissues have prevented their extensive use. Attempts have also been made to evolve a means of continuous recording by making use of the varying size of the oscillations imparted by the artery to the blood pressure cuff. The large number of variables involved in this procedure has rendered it relatively ineffective. A second difficulty is one which has already been referred to, namely, the inadequacy of many of the laboratory stimuli which have been utilized as a means of evoking the emotional response. The most successful laboratory stimuli have been those which Watson originally described as being effective in very young infants, namely, loud noises and withdrawal of support. Finally, a good deal of the confusion concerning the blood pressure responses has undoubtedly been due to a failure to differentiate between a mood and an emotional response. This will be discussed in the section on mood.

In the normal individual the most frequent response to a stimulus having an emotional meaning for the individual is a rise in blood pressure. Both systolic and diastolic pressures rise but not proportionately. Cameron (unpublished data) studied a group of individuals who were actively stimulated by discussion of painful topics. The systolic-diastolic r fell appreciably. This is of interest in view of the fact that the administration of adrenalin subcutaneously also produces a fall in the systolic-diastolic r (Freeman and Carmichael, 1935).

Attempts have been made to differentiate emotionally unstable individuals on the basis of the extent and frequency of their blood pressure rises. So far it has been difficult to set up a standard situation in which the subject is to be studied. Armstrong (1938) has studied the blood pressure responses of candidates for the Air Force. In addition to a rigorous physical examination these individuals had a psychologic interview. As a result of his study Armstrong states that he found high correlations between individuals showing an undue degree of emotional hypertension, on the one hand, and a history of instability on the other. He also reports, however, that those individuals who had a high pulse rate together with a normal or low blood pressure were particularly unstable.

An increasing use is being made of the twenty-four-hour blood pressure curve. Since the day's activities cannot be completely standardized, it is clear that the curves cannot be interpreted too rigorously. In definitely unstable individuals the fluctuations of blood pressure throughout the day is considerably greater than might be produced by undetected variations in the day's routine. By this means it can be shown that in anxiety and panic states not only is there a general rise in the systolic and diastolic levels but the most marked feature is the considerable fluctuation in level.

The question of the psychogenesis of emotional hypertension has received much attention during the last few years (Fahrenkamp, 1926; Stokvis, 1938). No final statement is possible. Studies of the blood pressure curve in emotionally disturbed individuals show, however, that at least one theory concerning this is no longer tenable. The concept that a long continued emotional hypertension of 160/100 was gradually converted by structural changes in the vessels to an irreversible hypertension of the same value can no longer be supported. Study of the blood pressure curve readily shows that a rise of 60 mm. Hg. over the basal fasting level may occur for a few minutes or even an hour or two in response to an acutely disturbing situation. The organism cannot, however, continue to function within normal ranges if the degree of emotional disturbance necessary to produce that degree of blood pressure rise persists. In practice one finds that such rises are in the great majority of cases episodic, usually lasting only a few minutes. In those cases in which an emotional reaction of such severity as to produce a hypertension of over 40 mm. Hg. persists for periods of longer than twenty-four hours, one usually finds that thinking becomes severely disturbed; there is continued inhibition of higher level functioning which is not directed toward the topics of concern, and the individual begins to show the usual picture of agitated depression. There is no indication that these cases are particularly prone to show a persistent hypertension on recovery. If emotional factors are responsible for the eventual development of essential hypertension or at least of some of the cases included in this category, it seems probable that the mechanism is rather different. Either a persistent emotional hypertension of 20 to 30 mm.

Hg., which can be borne over long periods without serious disturbance of the higher level functions, may result through structural change in a gradual rise of the basal fasting level and a consequent rise in the emotional hypertensive level, or it may be that frequent large though transitory blood pressure rises found in emotionally unstable individuals may also produce gradual adaptive alterations in the form of structural change.

Considerable interest has been directed toward the use of the blood pressure curve during sleep as a means of differentiating hypertension of an emotional origin from irreversible hypertension. While it is true that the fall in night pressure is much greater in the former than in the latter, it must be borne in mind that, as in the case of the pulse, tensional factors apparently continue to operate, though in diminished degree, during the night. Moreover, it can be readily shown that prolonged rest in bed will produce a limited amount of fall in the night pressures even in cases of irreversible hypertension.

Blood Sugar. The work which has already been done upon this variable has served to show that its range of usefulness as a means of clarifying the nature of the emotional reaction is limited. Fluctuations in the blood sugar level take place too slowly to permit of the emergence of the meaning which moment to moment happenings have for the individual. Even when a change in the blood sugar level can be definitely ascribed to a given event, the temporal relations between the blood sugar rise and variations in the stimulating situation are so delayed and the blood sugar changes tend to be so smoothed out that a detailed analysis of the organismal-environmental relationship can rarely be made. As will be shown, this method of study has been of distinct value in differentiating between different kinds of affective response.

It is of interest to note that hyperglycemia in response to emotional excitation is a widespread type of reaction. Britton and Kline (1939) have reported its occurrence in a series of species extending from the higher mammals down to the reptiles. They were not, however, able to demonstrate any definite correspondence after emotional stimulation between the psychosomatic expressions or the blood sugar or temperature changes within individuals or in species. It is now generally agreed that provocation in the normal individual of a severe emotional reaction will elicit a definite hyperglycemia (Dobreff and Tomoff, 1932; Gildea, Mailhouse and Morris, 1935). The earlier contradictory reports were largely due to the failure to obtain severe emotional reactions and also to a failure to differentiate between a mood disorder and an emotional reaction. It is becoming apparent that the mild emotional reactions, provoked by viewing pictures or by conversation upon distressing topics, fail, as a rule, to elicit hyperglycemia.

The more severe reactions, such as those present in persons awaiting operation or those who have just witnessed or participated in serious accidents, are frequently accompanied by a definite, though not severe, hyperglycemia. During emotional reactions, which were of rather longer duration and perhaps approximated tension states, the glucose tolerance curve falls (Diethelm, 1936). It is interesting and important to note that when the reaction was one of pure elation or depression there was no abnormality of the tolerance curve. It is possible that the abnormalities of the glucose tolerance curve, which led McCowan and Quastel (1931) to set up a hyperglycemic index, were also dependent upon states of tension or emotional reactions occurring in association with the mood disorders rather than upon the mood disorders themselves. The index

$$\frac{\text{Two hour blood sugar level} - \text{fasting level}}{\text{Maximum blood sugar level} - \text{fasting level}} \times 100$$

gave a reacting which varied from zero to a hundred. Zero to ten was considered normal and values ranging up from this point denoted varying degrees of abnormality. The authors considered that a close degree of correlation existed between this index and the intensity of the emotional reaction.

Our own experience has shown a considerable degree of correlation in a certain proportion of cases with rather complete failure in other apparently comparable situations. It seems possible that further exploration of this measure might serve to differentiate patterns of emotional and tensional response.

Respiratory Cycle. There is general agreement that the respiratory cycle participates in the emotional reaction. Direct observation can readily demonstrate the fact that the respiratory rate is increased in persons suffering from fear, anxiety or anger. In children more severe anger or fear reactions may lead to momentary suspension of respiration. The phenomena of sighing and of sobbing are clearly related to emotional and tensional activity. Finally we may point to the growing literature upon the emotional factor in asthma.

In view of this considerable range of respiratory phenomena, associated by fairly general agreement with the emotional reaction, it is rather astonishing how conflicting the results of experimental work have been. One of the outstanding causes of this is the fact that, as is the case in many other functions, the respiratory mechanism does not subserve only the respiratory function. To borrow a term, it is the final common pathway for several functions. In addition to supplying the means whereby the respiratory function can be carried out, it also provides a large part of the mechanism of speech and part of the mechanism whereby temperature regulation is carried out. With regard to its participation in speech it has been shown (Golla and Antonovitch, 1929) that individuals who have an auditory type of imagery frequently show an irregular type of respiratory cycle. It is suggested that this irregularity represents subvocal speech.

In the simple undifferentiated emotional response, such as the startle reaction, the respiration pattern consists in a temporary arrest, usually followed by an increase in rate or amplitude or both. There may be some irregularity of the pattern which persists for several minutes.

The relation of milder emotional reactions, characterized by pleasantness or unpleasantness, is obscure. Numerous workers (Rehwoldt, 1911; Cason and Cason, 1933) have reported most conflicting results. In part this appears to be due to the difficulty of obtaining an adequate stimulus situation and in part it appears to be due to technical difficulties of registration. A method such as that advocated by Haldane (1922), whereby the individual, save for his head, is entirely enclosed in a rigid container which is connected with a recording device, is valuable when the total respiratory cycle is under enquiry. Clearly it can offer no information as to the contribution made by the abdominal or thoracic mechanism. The use of tracings from the basal metabolism apparatus encounters the same difficulties and moreover the necessity of breathing through a mouthpiece creates a definitely artificial situation. Investigations into respiratory activity during emotional reaction in psychoneurotics (Finesinger, 1937) has shown that no general statement can be made. In those patients who did show changes in their respiratory cycle there tended to be an increase in rate of both inspiration and expiration and an increase in amplitude during unpleasant emotions.

Paterson and Jung (1907) were unable to find any correlation between respiratory changes and psycho-galvanic tracings in persons in whom an emotional reaction was produced.

They suggest that this might be due in part to the fact that the respiratory cycle is influenced by many variables. They considered that, when the respiratory cycle was affected by an emotional reaction, this interference most frequently occurred during the expiratory phase. This observation has never been adequately followed up but is clearly of interest in connection with the psychogenesis of asthma.

Heat Regulation. Numerous workers (Zeigler and Levine, 1925; Segal *et al.*, 1928) have reported that the oxygen consumption rate is definitely raised by the occurrence of an emotional reaction. This fact is now so clearly recognized as to be incorporated into the technique of estimating the basal metabolic rate. Certain problems of considerable practical importance arise from this phenomenon. Among these is the difficulty which may arise in differentiating between hyperthyroidism and states of prolonged tension. In spite of repeated claims in the literature that hyperthyroidism is always of psychogenic origin, the evidence is not yet conclusive; and the fact that there is a considerable fall in the night pulse rate in tensional states, as contrasted with hyperthyroid states, tends to support the contention that a hyperthyroidism of non-psychogenic origin certainly exists. It has been reported (Grafe and Meyer, 1923) that the basal metabolic rate can be increased by attempting to evoke an emotional reaction under hypnosis.

In recent years studies have been made of local variations in heat control. It has long been known that a certain number of individuals, showing various types of abnormal behavior, suffer from cold extremities. Wolf and Mittelmann (1937) found that a fall in the temperature of the extremities could be produced in subjects in whom emotional reactions were elicited. It is of interest to note that it was found that the subjects showed differential emotional reactions. In some the gastro-intestinal function participated much more extensively than did the skin, and vice versa. It is also of interest to note that, in persons who were already tense, there was a much sharper response to emotional stimulus than in those who were at ease. We have noted a similar phenomenon in connection with the blood pressure response or elicitation of an emotional reaction. Zeigler and Cash (1938) investigated extensive areas of the skin. They found that during an emotional response the area of maximum temperature fluctuation is the face. They also report that a rise in temperature, as well as a temperature fall, may occur as part of the emotional reaction. Clearly this type of approach may be of significance in hypochondriasis.

Gastro-Intestinal Activity. It has long been known (LeConte, 1900; Cannon, 1902) that gastro-intestinal movements and gastric secretion are inhibited during a strong emotional reaction. The earlier work was done on animals but similar results were subsequently obtained in the case of the human organism (Landis, 1926). Since these earlier experiments, work has been carried on in two major directions, first, in an attempt to prove or disprove the James-Lange theory; secondly, in the form of investigation as to the possible psychogenesis of gastro-intestinal disorders.

The first line of investigation has been carried on either by means of fluoroscopic studies or by means of balloons introduced into the stomach and rectum.

Though both methods have tended to confirm the earlier observations concerning the inhibitory effects of strong emotional reaction, no definite statement is possible concerning the temporal relations of this inhibition of activity and the emotional reaction as perceived by the subject. Hence it has been impossible, at least by this method, to obtain conclusive evidence concerning the James-Lange theory.

Some of the earlier work on animals suggests that emotional reaction, characterized by pleasure, tended to facilitate gastro-intestinal activity while the emotions of fear and anger tended to inhibit them. Brunswick (1924), in an extensive investigation, found that there were numerous contradictions of this theory. While fear and irritation might be associated with a reduction in activity, the subject might report distress and surprise at a time when his gastro-intestinal activity was increased. Brunswick suggests that, in attempting to explain these rather contradictory findings, attention should be paid to the subject's own reaction to his emotional response. He considers that the fear reaction is mediated through the sympathetic and tends to produce inhibition of gastro-intestinal activity.

If, despite his fear, the subject attempts to carry through, encouraging himself by saying, "I can do it," "I will do it," the parasympathetic, according to Brunswick, is called into action and the original gastro-intestinal pattern is interfered with.

The other line of enquiry, namely, as to the effects of the emotional reaction upon the psychogenesis of gastro-intestinal disorders, is being pushed actively under the impetus of the present interest in psychosomatic medicine (Dunbar, 1938). There are frequent reports on the effects of emotional factors in the production of "nervous dyspepsia." Emotional factors have long been suspected in the genesis of ulcers both in the gastric and duodenal regions. The part played by emotional disturbance in the production of diarrhea can almost be said to be common knowledge, and during the last decade interest has turned to a possible psychogenic origin of mucous colitis. Unfortunately, technical difficulties still interfere with the application of precise experimental procedures and, though some of the conclusions based upon complete observation appear reasonably secure, a final statement must be deferred, at least with regard to some of the more obscure relationships such as may exist with respect to mucous colitis and ulcers of the gastro-intestinal tract.

Electrical Reactions. Studies of the effects of the emotional reaction upon the electrical activity of the brain have shown (Hoagland, Cameron, Rubin, 1938) that there is an increase in the delta index when situations, having a known emotional significance for the subject, are discussed in his presence. It was found, moreover, that, while the pulse rate rose during such reactions, the pulse rate rises associated with such conative activities as counting silently were not accompanied by variations in the delta index. This suggests that the delta index fluctuations correspond more closely with the subjective experience of emotion than do pulse rate variations. In a further series of investigations simultaneous records were taken from the cortex and from a region near the hypothalamus. The same phenomena were noted, and it was found that the evidence of disturbance in electrical activity, due to the emotional response, appeared in the record from the cortex a few milliseconds later than it did in the record from the region of the hypothalamus. Oberman (1939) has also investigated the electrical activity of the brain during an emotional reaction and reports that he has found a depression of alpha activities.

Precise information regarding the electrical activity of the skin during an emotional reaction is still lacking despite the fact that we have been in the possession of relatively delicate means of measurement of the phenomena for more than sixty years. The changes to which attention has been mainly directed are the electrical output, as picked up by electrodes placed on the skin, and the resistance to a current of external origin passing through the skin.

A major source of difficulty has been the lack of a precise definition of the emotional reaction and a failure to realize that this concept is actually comprised of several patterns of response, some of which are quite distantly related to each other. By means of simple questioning and direct observation we may obtain the information that the emotional reaction to threatening and dangerous situations arouses in the individual a feeling of fear; there are changes in facial expression, in coloring and in bodily posture. At the same time we may be able to record changes in blood pressure, pulse and respiratory rate, blood sugar and in the electrical activity of the skin. In many of the contributions to this topic of the emotional reaction one notes the underlying assumption that all these responses are present in every emotional reaction and indeed that any one of them can be taken as an index of the activity of the others.

Careful consideration shows that this is far from the case. There are individuals in whom the blood pressure is the major participant in the emotional reaction; in others it is the gastro-intestinal tract and in still others the actual feeling of fear may be minimal although there may be extensive lower level reactions. In this connection it is interesting to note that emotional hypertension does not entirely subside during sleep (Cameron, 1940). Twenty-four-hour blood pressure studies carried on during the course of recovery from an acute anxiety reaction will show that the blood pressures recorded during sleep, as well as those recorded during waking hours, will come down. This difficulty, due to failure to recognize the existence of patterns within the concept of the emotional reaction, is rendered still more serious by the fact that the tensional reaction and the reaction which we designate as a mood are also clearly related to the emotional response. Indeed, there are more grounds for considering that they are more readily differentiated on a quantitative than on a qualitative basis. In this connection it is of interest to note that tensional changes accompany all conative activities and also that it has been reported that electrical changes in the skin are associated with conative rather than with emotional activities (Aveling, 1929).

From the extensive work which has been done upon the electrical activities of the skin it may readily be seen that we are by no means clear as to which aspect of the emotional reaction is most highly correlated in these activities. Indeed, it seems probable that these activities may occur in association with an aspect of the emotional reaction which is not essential and at times when, in terms of our present concepts, no emotional reaction was taking place. At the present time it seems desirable that more work should be done upon the electrical changes as phenomena in themselves rather than that attempts should be made to use these changes as a means of understanding the emotional reaction.

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CHAPTER X

FACILITATIVE FUNCTIONS (*Concluded*)

Locus of Emotional Response. It has been stated that the earlier concept of an emotional reaction which is uniform from individual to individual, save perhaps in the matter of intensity, is a concept which is quite limited in its productivity. Experience shows that the reaction is one which is most protean in its manifestations. There are numerous patterns of response, all of which may reasonably be included within the generic term emotional reaction. These patterns vary from person to person and, possibly, though precise data are not yet available, also within the same individual from time to time. One may mention typical patterns in which the main participants are — subjective experience + cardiovascular + skin functions, or subjective experience + gastro-intestinal + renal + slight subjective experience or cardiovascular + skin + no subjective experience as in dreamless sleep.

It is clear that if we work with this concept of a series of emotional reaction patterns, the appearance of which is in part dependent upon the organization and set of the individual and also perhaps upon the type of demand which the environment is making, the idea of a location or seat of the emotional reaction becomes rather nebulous. Much of the work which has been done upon this question of defining the seat of the emotional reaction has clearly been influenced by a concept of the subjective experience of the emotional reaction as being the dominant and, for the James-Lange adherents, the initiating component of the whole reaction. More extended work seems likely to supersede this concept. It can readily be shown that the correlation between the subjective experience and the rest of the response, while positive, is not high. In other words, the subjective experience and the rest of the response may fluctuate with a certain degree of independence of each other. As a continuation of this line of thought it can be demonstrated that at least that part of the emotional reaction, which is integrated through the autonomic, may be detected as active during dreamless sleep. Finally, in spite of extensive work, it has not yet been possible to correlate different types of subjective experience with definite patterns of participation by the lower functional levels. We cannot determine, by simple inspection of records of cardiovascular or respiratory functioning during an emotional reaction, that the organism was experiencing fear or rage at that time.

Nevertheless, if one bears in mind that the subjective experience is simply one component of the many which may form an emotional reaction pattern, it is of value to review the work which has been done in an attempt to locate the origin of the emotional experience.

This work has for the most part centered about attempts to validate one or the other of two theories. These are the James-Lange and the thalamic concepts of the origin of the subjective component of the emotional reaction. In brief the James-Lange theory states that in an emotional reaction the lower level functions respond first, and it is the perception of these responses, particularly those of the viscera and the cardiovascular system, which constitute the subjective experience. No final decision has been achieved concerning the validity of this concept. The major difficulties which it encounters are that first, no patterns of visceral or cardiovascular response have been worked out to correlate with the great range of subjective emotional experience; secondly, in animal experiments, removal of the sympathetic division resulting in complete interference with those visceral activities which have been postulated as originating the subjective emotional response, had no effect so far as could be judged by observation upon the emotional behavior of the animals (Cannon, Lewis, Britton, 1927). Dana (1921) reports that, where fracture of the neck had occurred with complete loss of all superficial and deep sensation from the cervical region down, there was no loss in the capacity to experience an emotional reaction. While rejecting the James-Lange theory he suggests that subjective experience of emotion is evoked centrally and that the peripheral manifestations tend to reenforce this feeling. A man who is afraid may find his fear augmented by the fact that his heart is pounding, his hands wet and his legs trembling.

The theory of a central location for the feeling of emotion tentatively suggested by Dana (1921) was elaborated by Cannon (1927, 1931). As currently stated, this theory suggests that the subjective component of the emotional reaction arises from interaction between the cortex and the diencephalon. Several variations of this viewpoint are advocated. That which is most commonly held is that the diencephalon, stimulated either directly during the transmission to the cortex of the incoming stimulus or secondarily from the cortex after the stimulus has been received by that structure, imparts an emotional component to what has been apperceived through this stimulation of the higher levels of the brain.

Little direct evidence, however, exists to support this contention. It has been shown by numerous workers that the lower part of the diencephalon contains motor centers for the integration of some, perhaps of the majority, of the patterns of emotional response. The evidence for this is well summarized by Bard (1934). This work has been almost exclusively carried out in lower animals but Grinker (1938) has shown in man that electrical stimulation by means of an electrode, inserted through the nares and impinging on the outside of the skull in the vicinity of the hypothalamus, can produce dilatation of the pupils, systolic blood pressure increments up to 80 mm. Hg., and marked changes in the circulation. Unfortunately, he makes no statement of the subjective emotional response during this stimulation.

A second line of argument which has been advanced is to the effect that occasionally one finds that thalamic lesions are associated with an unpleasant hyperesthesia. This will hardly stand close inspection, however, since it is now generally agreed that sensory and affective experiences, while they do, on occasion, assume the rôle of cause and effect with relationship to each other, are nevertheless separate phenomena.

Mood. Some confusion has been introduced into the study of the emotional reaction by a failure to recognize that the emotional response and the mood are not identical. One finds, for example, that extensive investigations have been carried out upon individuals suffering intense mood reactions and the results employed to criticize findings obtained from the study of the emotional reaction. For example, Whitehorn (1934) studied the fasting blood sugar in a group of 958 subjects, including a large number of manic-depressive patients and patients suffering from depression occurring at the involutional period. From the fact that little or no hyperglycemia was found, he states that he feels justified in expressing a considerable degree of skepticism as to whether hyperglycemia occurs during extreme emotional excitement in non-psychotic persons. Work is available, however, to indicate that where more care is exercised to differentiate between the emotional reaction and the mood, hyperglycemia can be shown to accompany the former (Gildea, Mailhouse, Morris, 1935).

A precise statement which would serve to differentiate these two forms of affective reaction is difficult to make. The following, however, may reasonably be stated — the emotional reaction is of shorter duration and is usually of greater intensity. Young (1937) states further that an emotion is a disruptive activity whereas a mood produces relatively little disruption. Clearly this statement is true only of the less intense mood reactions. Very considerable behavioral disruption occurs in severe, agitated depressions. Further confusion is occasioned by the fact that an emotional reaction may pass over into a mood. Some observers have stated that a mood is the "tail end" of an emotional reaction. Common experience, however, shows that the subjective component of an emotional reaction and a mood differ considerably. There is no doubt that there is a definite experiential difference between a feeling of depression and a feeling of fear, or between anger and cheerfulness.

The factors governing mood changes are still rather inadequately understood. Young (1937) states that unpleasant moods are frequently dependent upon such endogenous factors as fatigue, loss of sleep, or disease while pleasant moods are usually associated with normal functioning of the organism. He recognizes, however, that exogenous factors, such as success or failure, are frequently effective in producing mood changes. Sullivan (1922) states that such an environmental factor as the weather influenced the reports of a group of students as to their feeling of cheerfulness or depression.

The survival value of mood variation is not clear. It is generally recognized that performance is improved, at least in regard to speed, during cheerfulness (Fischer, 1934), but there is no general agreement as to the value of a depressive mood. It is possible that, during the limitation of activity associated with a depressive mood, readjustments may be carried forward which would be retarded were the energies of the individual diversified among the numerous pursuits usually carried out during those times when the mood is more neutral. In considering the value of the mood reactions it is important to note that it is generally reported (Morgan, Mull, Washburn, 1919; Young, 1937) that the depressive group of mood reaction occurs less frequently than do those which are characterized by cheerfulness. Most of the reported work, however, has been carried out on students, and little information is available as to the prevalence of depressive mood reaction as contrasted with cheerful responses at the older age levels.

The amount of work carried out upon the higher level functions during the more intense mood reactions is definitely limited. Much of the earlier work was devoted to devising means whereby the variations in psychomotor activity, which are so striking in the manic depressive reaction, might be rendered susceptible to experimental methods. For this reason extensive work was carried out upon the reaction time.

Reaction Time. Earlier workers entertained the hope that studies of the reaction time would not only open the way to a better understanding of the marked variations in psychomotor activity but would also provide a means whereby the differential diagnoses of the manic depressive reaction might be refined. It was readily shown that the reaction time was prolonged during the depressive reaction (Franz, 1906), but it could also be shown that the reaction time was prolonged during periods of psychomotor overactivity, as represented by the manic reaction. Furthermore, it was reported that the degree of prolongation of the reaction time could not be correlated with the degree of psychomotor retardation (Wells and Kelley, 1922). Most workers are now in agreement that not only are the reaction times generally increased whenever behavior becomes disordered but also that the variability in reaction, which was reported as occurring only in the manic depressive reaction, is also found in other forms of abnormal behavior.

Work which also has a bearing upon the speed of reaction in the mood response was reported by Diefendorf and Dodge (1908) who studied the ocular movements. They found that the movements were definitely slowed during the mood responses, the degree of slowing being rather greater in the depressive reactions than in the excitements. In general, however, the reaction time technique as a means of obtaining further information concerning the mood reactions has been inadequate. In one of the most recent reports upon the utilization of this procedure (Saunders and Isaacs, 1929), it is suggested that more value might accrue to the method if it were devised in such a way that a prolonged study could be made and also that the reaction of integrated functions, rather than simple activities, could be studied.

Concept Formation. This field has hardly been entered. Stransky (1935), impressed by the Ebbinghaus (1885) nonsense syllable technique for the investigation of memory, has devised a method whereby letters have to be interposed to make words. He presented a series of such tests to groups of normals, psychopaths, patients suffering from mild manic depressive reactions, and patients showing mild schizophrenic disorders. He found that there was a considerable slowing and a higher failure rate in the manic depressive reaction. These abnormal reactions were obtained in both the manic and the depressive phase; the failure rate was higher than was the case in the schizophrenic group. Further data on concept formation in the depressive reaction were reported by Hunt and Guilford (1933) and by Cameron (1936) who studied the responses of patients to the Necker cube phenomenon. This figure is so drawn that the observer's concept of its form fluctuates from moment to moment. Hunt and Guilford showed that the speed of fluctuation was definitely reduced in both manic and depressive patients. Cameron, using a similar type of figure, showed that the rate at which the figure fluctuated in persons suffering from a depression was low and tended to increase as the depressive reaction subsided. This could be demonstrated both in those patients in which there was a well marked morning depression with evening remissions and also in those cases in which the patient's depressive reaction gradually subsided over a period of several months.

Other aspects of higher level functioning have not been explored to any extent. Neuman and Mather (1938) have reported a study of the use of language during the depressive and the manic reaction. A considerable degree of differentiation was possible between the two types of response; and, moreover, fluctuation in the criteria followed could be correlated with fluctuations in the clinical condition. These workers included in their study not only intonation and pitch but also the structure of the language used. With regard to the latter aspect they found that in the depressive reaction there was little syntactic elaboration as contrasted with the manic reaction, in which it was high. Similarly, while the manic was quick in his response, the responses being long and rather rambling, in the depressive the response was slow, short and limited to one topic.

While study of the higher level activities in the extreme mood reaction has attracted a limited amount of interest, the work on the lower level activities during these reactions has been more considerable.

Carbohydrate Metabolism. Influenced largely by Cannon's work upon emotional glycosuria and hyperglycemia, a great deal of effort has been devoted to the question of whether similar changes occur during the mood reactions. Reference was made earlier to the fact that failure to recognize that a difference exists between the emotional and the mood reactions has resulted in a certain amount of confusion in this field. It seems probable that, when the mood reaction is not complicated by unusual tension and when the individual is not showing a transient emotional reaction over and above his mood, the fasting blood sugar will remain within normal limits (Looney, 1924; Bowman and Kasanin, 1929). When extreme tension complicates the picture, as in states of agitated depression or in some of the depressions occurring during the involutional period, the fasting blood sugar level is likely to be raised.

Deviations from normal are found rather more frequently if the glucose tolerance is investigated. The most commonly reported deviation is a delay in return to the fasting level (Mann, 1925). Raphael, Ferguson and Searle (1928) have reported the case of an individual, suffering from a depressive reaction, in whom repeated glucose tolerance studies were made throughout the course of his illness. At the outset a high blood sugar peak and a delayed return to normal were reported. As the reaction became more severe these deviations became more accentuated. Later, as the patient progressed toward recovery, the curve tended gradually to approximate the normal. These deviations are mainly reported in the depressive reaction and, like the fasting blood sugar level, they appear to be directly correlated with the degree of tension which is present. This correlation has been recognized and utilized by McCowan and Quastel (1931) in devising their hyperglycemic index. This is obtained as follows:

$$\frac{\text{Two hour blood sugar level} - \text{fasting level}}{\text{Maximum blood sugar level} - \text{fasting level}} \times 100$$

They report that they found a good correlation between the index and the degree of tension from which the patient was suffering. The index ranges from a normal of zero to ten (to allow for experimental error in technique) to a hundred as indicating maximum disturbance. They found it of value in detecting patients who were endeavoring to minimize their true condition in order to obtain their discharge and also in detecting those cases of emotional disorder in which there was a large "hysterical" element. From our own experience with approximately one hundred cases the index was found to be a fairly good guide provided care was taken to assess the reaction of the individual during the actual time that the tolerance curve was being run. Naturally pituitary and pancreatic disease must be eliminated.

Blood Pressure. The activity of this function during the more marked mood responses has long been under investigation. Paton (1905) reported that the blood pressure tended to be high in depressive reactions and low during manic attacks. Ballard (1917) and Buckley (1920) agreed that the pressure was elevated during depressive mood reactions. Later work has tended to show that these assertions require some qualification. Perkins (1927), who investigated an extensive series of patients suffering from mood disorders, states that there was an elevation when the patient was examined early in his disorder, when the reaction had persisted over an extended period, however, the blood pressure levels tended to approximate normal. Further progress was made by Gillespie (1926) who showed that there was considerable fluctuation in the blood pressure during the mood reaction and that one or two readings could not afford an adequate picture. He also noted that the systolic pressure was not persistently elevated above normal. Cameron (1940) has reported the recording of hourly blood pressures over periods of twenty-four hours on repeated occasions throughout the course of a mood response. From these records it can be seen that the variability of the blood pressure curve is just as important as the elevation of the pressure. As the mood response subsides, both the elevation of the pressure and the variability subside. It is of interest to note that, when there is a definite elevation, this tends to persist even during the hours of sleep. This fact lends weight to the assertion made earlier that the conscious correlate of the mood response should not be accorded undue importance in considering the response as a whole.

Gastro-Intestinal Activity. The amount of work done in this field has been rather limited, and the results already reported await further confirmation and elucidation. Henry (1924, 1931) has found that the movements of the gastro-intestinal tract are reduced during the depressive reaction and that, to some extent, this reduction is positively correlated with the severity of the general psychomotor retardation. He states that in severe depressions food may remain in the tract for more than two weeks after ingestion. Apparently there is also some tendency for slowing of peristaltic movements in the manic reaction, but in the hypomanic state food is passed on more rapidly than in the normal. The studies of Farr and Lueders (1923) and Farr, Lueders and Bond (1925) fail to throw additional light upon the problem. It is not clear from their reports when they considered that they were dealing with an emotional response and when with a mood. The general impression which one obtains is that long continued depression exerts little influence upon gastric secretion or upon the motivity of the gastro-intestinal tract, while acute emotional reactions exert an inhibitory action upon at least the gastric secretion.

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CHAPTER XI

SLEEP AND ALLIED REACTIONS

We propose to include under this heading all those activities which result in great reduction in, or cessation of, interpersonal relations. It is clear that while sleep, narcolepsy, the various types of stupor, and the states of unconsciousness, arising from the action of drugs as well as from trauma, may have varied causes, nevertheless there are certain fundamental similarities which render it profitable to consider them together.

Sleep. No acceptable theory of the mechanisms of sleep has yet appeared. In the last few decades work has been carried out on four major concepts. It has been suggested that sleep may be produced by a gradual accumulation of toxin. However, no toxin has been isolated, nor is there a satisfactory explanation of its origin. A second theory has postulated cerebral vascular changes as the major factor. Evidence is, however, available that both cerebral anemia and cerebral congestion may be found during sleep. Since sleep can be induced in animals by failing to reenforce the conditioned stimulus by means of the unconditioned stimulus, it has been suggested that sleep may be considered as a general cortical inhibition. Finally, it has been suggested that sleep may be considered as representing a periodic retreat from reality. Experimental data to support any of these points of view are all but lacking.

Some work has been done which appears to indicate that the hypothalamus may play an important part in the control of sleep. Tumors in that region have been frequently reported as associated with the appearance of pathological sleep (Fulton and Bailey, 1929). Sedative drugs administered to animals have been found on post mortem examination to be present in maximum concentration in that area (Keeser and Keeser, 1927), and it has been demonstrated that the injection of calcium (Demole, 1927) in the region of the tuber cinereum will also produce sleep.

Hess (1931, 1932) has suggested that sleep is primarily dependent upon the activity of the vagal division of the autonomic nervous system. He has reported experimental work in which ergotamine was injected into the third ventricle in animals. Following this, sleep, apparently closely resembling that which occurs under normal circumstances, appeared and lasted for several hours. However, since other agents introduced into the same region have also produced a similar reaction, the question whether ergotamine acts in this regard by virtue of its vagotonic action or simply as a nonspecific irritant must be considered.

Work upon the actual phenomena of sleep has encountered some difficulty in so far as it is not easy to state criteria of sleep. Apart from the gradual loss of subjective experience there are few changes which differentiate rest from sleep. The pulse rate tends to drop (Boas, 1929) as does the basal metabolic rate (Mason and Benedict, 1929). There is also a fall in blood pressure. One of the more constant phenomena is interference with the alpha rhythm as recorded by the electroencephalograph. This interference usually takes the form of the appearance of large slow waves. This indication has the advantage of appearing early in the onset of drowsiness. In deep sleep the alpha rhythm may disappear entirely.

There is a great increase of the threshold for the various forms of sensory stimulation, and motility, though not abolished, is greatly decreased. Jenners and Wible (1937) have contrasted the activity of the cardiac and respiratory functions during ordinary and hypnotic sleep. In the former they find that the pulse falls within about ten minutes after sleep has been established and that the respiratory rate becomes slower. In nearly half the records a Cheyne-Stokes pattern was established during ordinary sleep. These phenomena were entirely absent during hypnotic sleep, and the authors suggest that this form of sleep resembles the waking state rather than true sleep.

The effects of prolonged sleeplessness in the normal subject have been studied extensively. Contrary to expectation, prolonged loss of sleep has not been demonstrated to produce definite effects upon memory, capacity to carry out intelligence tests, reaction time or upon the metabolic rate. Katz and Landis (1935) report the case of a man who abstained from all save very short periods of sleep for two hundred and thirty-one hours. At the end of that period his lower level functions showed little deviation from normal. Tests of intellectual ability were negative. The subject did show an increasing disorientation, irritability and tendency to projection.

Considerable attention has been directed to the study of mobility during sleep as it occurs in various types of behavior reaction. Page (1935) has reported a comparison of the sleeping mobility of groups of manic, Parkinsonian, normal and catatonic individuals. During the waking hours these groups showed activity in decreasing amount as listed above. During sleep the groups retained the same relationship to each other, but the differences between each group were greatly reduced; there was a tendency on the part of the catatonic group to register more major movements during the day than during the night. Mullin, Kleitman and Titelbaum (1939) have investigated the nocturnal mobility of groups showing psychoneurotic, schizophrenic and affective reactions. They were unable to distinguish the groups on the basis of their mobility, but considered that normal individuals tended to show a greater amount of mobility and that that mobility was more extensive in the case of the normal individuals during the latter half of the night.

Stupor. Of the various types of stupor the catatonic has attracted most investigative interest. Many workers who have entered the schizophrenic field have felt disquieted by the difficulty of obtaining a generally acceptable definition of the reaction with which they were attempting to deal. There has been for several decades a conviction that the term schizophrenia probably covers a number of reactions which have only certain aspects in common. It is well known, moreover, that considerable difficulty exists in classifying those reactions which lie at the periphery of the schizophrenic concept. Surveys of repeated diagnoses in long term cases and of diagnoses made, on transferring the patient from one hospital to another, show that there is a considerable divergence of opinion as to what constitutes schizophrenia.

Much less doubt exists, however, in respect to the catatonic stupor which was defined with considerable precision by Kahlbaum (1874); and consequently it has been the object of much investigative work both on its own account and, less legitimately, as an easily defined representative of the schizophrenic reaction. Though it is common knowledge that the catatonic stupor may pass over into any of the other schizophrenic subtypes or may terminate in a dementia which is practically indistinguishable from the dementia reached by patients whose early symptoms were those of hebephrenia, there are aspects of the catatonic reaction which tend to separate it from the main schizophrenic group. Among these are the higher spontaneous recovery rate, the frequency of tensional states and the extreme emotional outbursts. Its value is further limited by the fact that catatonic stupor is found in only 2 to 3 per cent of schizophrenic cases, and the fact that its very nature tends to preclude investigation of higher level functions.

Among the more characteristic phenomena of catatonic stupor are the decrease in activity and the maintenance of assumed postures. Several investigators have shown that, while the average waking activity of a group of catatonic individuals is considerably less than that of the average for a comparable group of normal individuals, much less difference exists during sleep (Page 1935). It has also been shown that flexibilitas cerea disappears as soon as sleep supervenes (Forbes, 1934). This suggests that at least these aspects of the catatonic reaction are dependent upon the activity of the higher functional levels. Attempts have been made to understand these motor phenomena of the catatonic reaction in terms of what is found in the normal. Actual experiment has shown that the total activity of some normals may fall to as low a level as that attained by at least the more active catatonic stupors. Janet (1929) considers that in catalepsy the unusual factor does not consist in the prolonged maintenance of postures. The normal individual may also hold objects, apparently without purpose, in his hand over long periods or may maintain positions especially when daydreaming. The important difference, according to Janet, is that in the one case happenings in the environment will arouse interest and attention and result in a change of posture, while in the catatonic this happens more rarely.

Work has also been directed toward differentiating the catatonic activity disturbances from those found in midbrain lesions, particularly Parkinsonism. Claude, Baruk, and Therenaud (1927) have shown that in catatonia there is a variable and irregular distribution of rigidity. The authors also maintain that in the catatonic reaction there is a psychic component which is appropriate to the posture assumed. Finally, myograms show, in addition to the usual resting rhythm, the appearance of longer disturbances such as one finds during voluntary contraction. Steger (1939) found that even in those patients, who only occasionally showed a catatonic reaction, myogram curves showed evidence of increased resistance. In those cases in which there were marked catatonic symptoms, relaxation was very poor and spastic curves were obtained. In patients in whom the catatonic reaction was of long duration, the myogram was reminiscent of what is found in cases suffering from brain injuries.

Chronaxie measurements carried out on stuporous catatonic patients have shown that there is a great increase in the variability of the readings. In general the values are increased. Last and Ström-Olsen (1936) are inclined to think that this is due to changes secondary to the prolonged maintenance of position. The maintenance of cataleptic postures has been the subject of enquiry from the point of view of the amount of energy which is required. Grafe (1911) carried out studies of the basal metabolic rate on ten patients suffering from more or less well marked stuporous catatonic reactions. He found that in several of the cases heat production was lowered and that, in general, it tended to be lower the more marked the stupor. The investigations, which were carefully controlled, were carried out over periods of several hours. Grafe states that a fall as great as 39 per cent, as contrasted with his normals, was encountered. Schill (1921) investigated the maintenance of posture by two stuporous catatonic patients. He reported that the increase in O_2 consumption, the rise in pulse and respiratory rate, and the increase in the amount of respired air and in the blood pressure were the same in his patients as in his normal group. Plaut (1924) reports investigation in the capacity of one catatonic patient to maintain postures. This patient was able to hold himself in a horizontal position, his head resting on one stool, his feet on another, for a period of 9½ minutes. A normal control could carry this out for only one minute. Studies of the metabolic rate during maintenance of the posture showed that the catatonic patient had a rise in rate which was only 25 per cent of that shown by the normal control. Gaylor and Wishart (1933) examined the metabolic cost of sustained postures in three patients, only one of whom was, however, a clear-cut case of catatonic stupor. In this patient it was found that, while there was an increase in basal metabolic rate on assuming a posture, this increase was definitely less than normal, and that, moreover, the rise in pulse rate was disproportionately small as contrasted with the rise in B. M. R. It is clear that, while there is some indication that the stuporous catatonic patient is able to maintain posture more economically than the normal individual, considerably more work is required both to establish the fact and to clarify the mechanism.

Apart from the studies carried out on these characteristic disturbances of activity, attention has been directed to certain aspects of lower level function during catatonic stupor.

The metabolism of nitrogen during this reaction has been intensively explored (Stokes, 1939). By far the most detailed studies are those reported by Gjessing (1932, 1938) who has carried out daily investigations on a series of catatonic patients over a period of years. He has demonstrated that fluctuations in the amount of nitrogen retention occur. He has been able to establish two types of correlation between the behavior and the degree of nitrogen retention. In the first type there is a gradual retention of nitrogen until a threshold is reached which is characteristic for the patient. When this is attained the reactive phase — either stupor or excitement — sets in and elimination starts. This may persist throughout the reactive phase and part of the quiescent period or it may terminate while the patient is still excited or stuporous, and nitrogen retention may set in. In the second type the reactive phase sets in when elimination has reached its lowest level. In these cases retention is carried on during the reactive phase. In cases where nitrogen retention appeared to be associated with the onset of the reactive phase, it was possible to prevent the appearance of this phase by lowering the nitrogen level by means of thyroxine and desiccated thyroid.

Investigations of vasomotor functioning during catatonic stupor have taken various directions. Jung and Carmichael (1937) stated that the peripheral vasoconstriction, cyanosis and occasional edema of the extremities which were frequently reported as occurring in stuporous cases are a function of the immobility of the patient. They were not able to demonstrate fundamental disturbance of the heat regulatory system in these cases and stated that the abnormal plethysmographic findings, reported by other workers, disappeared on warm days and whenever the extremities were brought to normal temperature. When this was done the skin vessels reacted normally to injections of adrenalin or histamine. Mays (1934) has reported the galvanic skin response as a means of studying the tendency of the autonomic nervous system to show perseveration in the catatonic patient.

The criteria chosen were the duration of the persistence of the galvanic skin response after repeated intense stimulation and the duration of persistence of the same magnitude of response throughout prolonged stimulation. Definite evidence of perseveration was obtained. It is clear that, by using the term perseveration in this sense, one is approaching the concept of a sluggish reactivity which has been reported by many workers in the schizophrenic field. No definite agreement concerning the degree of skin resistance in catatonic reaction is apparent. Forbes and Piotrowski (1938) state that they have found a greater degree of variability in skin resistance of catatonics during sleep and suggest that this may indicate some instability of autonomic nervous function.

Numerous attempts have been made to reproduce the catatonic reaction in animals. Bulbocapnine (deJong, 1922) has been the most successful of the numerous agents employed. Following injection in this drug in a suitable animal — usually a monkey, cat or mouse — there appears, within a few minutes, decreased activity which may progress to complete immobility, increased muscular tonus with catalepsy. Increased salivation with drooling is frequently observed and the electromyographic tracings resemble those obtained in human catatonia.

Negativism, both active and passive, has been described (Henry, 1931). With higher dosages overactivity and abnormal postures appear and with still higher doses epileptoid seizures may occur and result eventually in the death of the animal (deJong and Baruk, 1930). Unfortunately, in the human subject toxic symptoms appear early so that it has been necessary to confine the study of bulbocapnine catatonia to animals.

It has been claimed by deJong and Baruk (1928) that bulbocapnine catatonia appears most adequately in those animals in which there is a fully developed neocortex; the symptoms are absent or minimal in fish, lizards or snakes in which there is no neocortex, while birds, having a rudimentary neocortex, occupy an intermediate position with reference to the appearance of this form of experimental catatonia. Puech and Baruk (1937) have reported that removal of the prefrontal lobes in monkeys resulted in the appearance of a more marked experimental catatonia after the injection of bulbocapnine. Direct impregnation of the lobes by means of the drug produced no reaction.

Numerous other agents have been reported as eliciting the catatonic reaction in animals. Among these are urinary substances (Freud and Dingemanse, 1932), combined administration of mescalin and adrenalin (Noteboom, 1932), exposure to decreased atmospheric pressure (Jongbloed, 1934) and injections of a toxin derived from cultures of colon bacilli (Baruk, 1933).

Consideration of the data derived from experimental production of catatonic states in animals leads to two general conclusions. First, it is probably impossible to duplicate completely the human catatonic reaction in animals which are less highly differentiated. It is of interest to note that the higher the position of the experimental animal in the developmental scale the more the picture approximates that found in the human subject. It is also suggestive that the same agents which achieve release from the catatonic reaction in the human subject also abolish the reaction produced experimentally in animals. This will be discussed later. Secondly, we must conclude from the great diversity of agents, which are said to produce the reaction, that at least that form of catatonic reaction which we can produce experimentally is a relatively nonspecific reaction. It seems probable also that the range of causal agents has not been fully explored. The "freezing" of rabbits and other animals during fear states and the so-called hypnotic states, which can be produced in some of the lower animals, appear to have a kinship with experimental catatonia which has never been clearly worked out.

A further experimental attack upon the problem consists in the attempts which have been made to terminate the reaction, even if only temporarily. Among the first agents employed was cocaine (Berger, 1921; Fleck, 1924; Jacobi, 1927). This clearly had the disadvantages attendant upon the repeated use of cocaine and little further progress was made until the work of Loevenhardt and Lorentz (1929), first with sodium cyanide and later with high concentrations of CO_2 and O_2, developed a greatly increased interest in this line of approach. These authors had noted, as early as 1916, that the administration of sodium cyanide intravenously produced a transitory amelioration in one case of dementia precox. They were inclined to correlate this with the reduction in oxidation which is occasioned by the drug. In 1928 they made their first planned attempt to produce what they termed cerebral stimulation by the intravenous injection of 0.1 per cent sodium cyanide. For the attempt they utilized three stuporous, mute and resistive schizophrenic patients who showed considerable muscular rigidity. Following stimulation they became responsive to simple commands.

Repetition of this procedure, however, yielded unsatisfactory results, and a more effective stimulating agent was sought in mixtures of CO_2 and O_2. Mixtures of 10 to 15 percent CO_2 and 90 to 85 per cent O_2 were used at first. The authors note that, after this had been used for five to twenty minutes, evidence of cerebral stimulation could be observed. This consisted in a gradual arousal from the stupor. Definite response, moreover, could always be elicited if the CO_2 content was increased by not more than 5 per cent per minute up to a final concentration of 30 to 40 per cent. They consider that higher concentrations are not free from danger. Cerebral stimulation appeared several minutes after the cessation of the respiratory stimulation produced by carbon dioxide. This stimulation was demonstrated by the appearance of social contact, interest, and disappearance of the stiffness and rigidity. It usually lasted up to twenty-five minutes. The degree of contact possible varied considerably from patient to patient. In some cases only a few scattered words could be obtained; in others there was a coherent statement, sometimes an expression of complete insight. At the end of this period of stimulation a gradual reversal of the picture occurred; the patient became less and less communicative and finally returned to his former catatonic condition.

This stimulating approach has provoked a considerable amount of interest in the stuporous reaction. The mechanism whereby the diminution of the stupor is brought about remains obscure. D'Elseaux and Solomon (1933) have reported a comparative investigation of several methods used to abolish the stuporous reaction, but they were unable to postulate any set of psychobiologic factors which were common to all methods investigated. It is conceivable that the mechanism may not always be the same. The introduction of sodium amytal by Blackwen (1930) as a means of overcoming the stupor reaction has led to still further progress in this field. The drug was originally given in sufficiently large amounts intravenously to produce sleep. On rousing from this it was found that the patient, hitherto mute and inactive, was able to talk and move freely for a varying period. This rarely lasts more than a few hours. Lindemann (1931) modified the procedure by giving small amounts which are insufficient to produce sleep but do produce release from the catatonic stupor. These interesting findings have given rise to considerable speculation concerning the action of the drug. One of the more plausible concepts concerning its action invokes Cannon's hypothalamic theory of emotion and suggests that the action of the drug may be on cortico-hypothalamic connections. It is of interest to note that shortly after the concept of catatonia was first delineated by Kahlbaum, there was considerable opinion in favor of classifying the reaction with the affective disorders. Animal experimentation (Masserman, 1938) has shown that, while injection of sodium amytal directly into the hypothalamic area does not interfere with the possibility of emotional responses similar to those described by Bard as sham rage, intravenous injection of the drug does.

In considering the data concerning the release from catatonic stupor, it has been found that the catatonic reaction produced in animals by bulbocapnine can also be overcome by such agents as CO_2 in concentration of 35 to 50 per cent and also by cocaine (Buckman and Richter, 1933).

Investigations of the activity of the higher functional levels during the catatonic stupor reaction are naturally rendered difficult by the reduction not only of verbal communication but also of communication by means of gesture and changes in expression and attitude. Löwenstein (1920) has reported a detailed investigation of small movements of the head and limbs and variations in the pulse rate and respiratory movements which occurred in response to various stimuli. He found that stimuli which normally produced tension, relaxation, fear or pleasure elicited changes in the indices which he used. He claimed that these changes were similar in nature to those which are to be normally expected — the type of change correlated with the type of stimulus. In considering these findings it is to be borne in mind that continued investigation of the bodily responses to pleasure and aversion has not yet defined a constant pattern. For example, there is no general agreement that forward movements of the head are associated with pleasure and movements back from the stimulus are associated with aversion. Nevertheless, this should not detract from the value of the statement that response to verbal stimulus does take place in the stuporous reaction. Löwenstein was unable to determine, by means of his form of experimental technique, whether spontaneous activity at the higher functional levels occurred. He states that in several cases latency of response and the duration of the reaction appeared to be increased. Investigation of the actual thinking during the stupor reaction has been attempted by interrupting the reaction by means of sodium amytal and direct questioning of the individual concerning his major preoccupations. By this means Thorner (1938) investigated four of the outstanding aspects of the catatonic stupor reaction, namely mutism, refusal to eat, cerea flexibilitas and uncleanliness. He reports that the underlying basis for these aspects of the catatonic reaction appears to be an inability to choose between different lines of action.

During the earlier work upon catatonic stupor attempts were made to localize a possible pathological lesion. Several such lesions have been reported but there is little or no unanimity as to location; moreover, the fact that the reaction can be set aside by the various agents described above has tended to render the probability of a lesion, as we understand the term, still less likely.

The fact that the prognosis is good in a certain proportion of stupors, coupled with the observation that stupor-like reactions may occur during the course of a severe depression, have led to the view that types of stupor other than the catatonic may exist. This viewpoint was presented in great detail in Hoch's (1921) description of benign stupors. A follow-up of these cases by Rachlin (1935) has shown that the majority have progressed to an unmistakable schizophrenic reaction. Little or no experimental work has been done upon these so-called benign stupors. A similar statement must be made in regard to the hysterical stupors and even the hysterical twilight states.

Investigation of the states of unconsciousness associated with convulsive attacks has naturally encountered great difficulty. Pierce Clark (1917) endeavored to recreate the possible content of the attack by means of persistent questioning of the patient immediately after the convulsion had terminated. Diethelm (1930) has reported the investigation under hypnosis of petit mal attacks. It is of interest to note that, as the attack progressed, there was a concentric constriction of the field of vision; as the attack deepened the patient no longer saw his environment but reported that he had seen fantastic objects which often had a vortex or tubular form. As the attack subsided this process was reversed, the fantastic objects first disappearing and then the range of things which he could see in his vicinity gradually expanded each to its normal extent. The return of consciousness following upon the metrazol convulsion has been studied by Cohen (1939). Immediately following upon the seizure there was no response to a pin prick; later the patient tended to respond by a mass reaction. Still later there was a local defense reaction, the patient withdrawing the leg or arm which was pricked. Finally the patient could localize with increasing exactitude the point at which he was being pricked and could stretch out his hand to deal with the source of irritation. During this period of inexact localization of the pin prick it was found that the patient also had difficulty in locating sounds. He could turn his head about at random when his name was called. His ability to recognize objects was also impaired and tended to clear up before his ability to use even those objects which he recognized.

The states of unconsciousness associated with hypoglycemia and those following upon the use of convulsants such as metrazol will be considered in the sections dealing particularly with those conditions.

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CHAPTER XII

CONVULSIVE REACTIONS

The functioning of the organism may be interrupted by behavior which can be characterized as explosive and of short duration. The seizure or fit is usually thought of as the outstanding representative of this type of behavior. If one considers that, in addition to being explosive and of short duration, this behavior has the further characteristics that, once initiated, it can rarely be controlled by the organism, that it is of a sweeping nature resulting in the more or less complete suspension of all other activities and that it tends to be stereotyped in form — subsequent repetitions of the same activity showing a considerable resemblance to those that preceded them — one can readily see that the concept of convulsive reaction can be extended to include more than the actual fit.

Bearing in mind these characteristics, it seems reasonable to include the orgasm, the acts of vomiting, urinating, defecating and perhaps sighing, sneezing and yawning. It is clear that some of the latter are to varying degree under the control of the individual. They can be, for the most part, initiated by the individual, and with considerably less ease can be stopped. It is of interest to note that they all apparently result in some degree of release of tension. Not all these reactions have psychiatric significance and still fewer have been explored experimentally.

By far the greatest amount of work has been done upon the seizure. This work may conveniently be considered in terms of the investigations which have been carried out upon the form of the seizure either in whole or part, the investigations which have been directed toward determining the factors which are responsible for the seizure as it appears naturally, the work which has been done upon the experimental production of seizures and the studies which have been made upon the control both of the naturally occurring seizure and of that experimentally produced.

Phenomena of Seizure. Work in this field has been of necessity limited by the fact that the seizure reaction is relatively unpredictable in regard to its time of onset. For this reason a good deal of the work upon the actual mechanism of the seizure reaction has been carried out on seizures which have been produced by artificial means. This will be discussed in a later section. Reference has already been made in the chapter on sleep and allied reactions to the studies of the higher level functioning occurring during the epileptic seizure.

Little experimental work has been done upon the actual course of the seizure. Clinical observation has shown that the various components of the epileptic attack vary most considerably from patient to patient and possibly within the same patient, but practically nothing is known concerning the possibility of modifying the various phases or of the influence which, for example, a severe tonic phase may have upon the subsequent stages of the attack. Some use has been made (Löwenstein, 1933) of the recording of motion pictures of the seizure, but it is apparent that high speed camera studies will be necessary before more data can be obtained by this means than by simple observation, Electromyograms taken during the tonic phase have shown that the seizure is actually of tetanic rather than of tonic nature (Salomonson, 1920).

Certain aspects of lower level functioning during the epileptic fit have been studied. Scott and Pigott (1936) have investigated the serum calcium values in a series of 50 patients suffering from epileptic seizures. Samples were taken both during a a typical grand mal seizure and between attacks. The levels were within normal ranges and there was no evidence of an appreciable difference in the samples taken during a seizure and in those taken between attacks. This finding is of interest in view of the action of calcium upon muscle irritability. The behavior of serum phosphorus during the seizure has also been studied (Weil and Liebert, 1937). A rise of 34 per cent in men was found. The significance of this is not clear. From the animal experiments, which were carried out coincidentally, it would appear that the rise may be associated with the increase in muscular activity. Rabbits, which were given a convulsant dose of thujone but which were immobilized by means of curare, did not show the rise in the serum phosphorus level which they regularly showed when they were not immobilized. Further work on the blood minerals during the epileptic seizure is reported by Hirschfelder and Haury (1935). Blood taken during or just before epileptic attacks in 35 cases showed that there was a tendency toward a low plasma magnesium and a high plasma potassium. This tendency was more marked in those patients in whom the attacks were more severe. There was no deviation from normal in a group of 17 epileptics who were not having seizures. The significance of these findings is unknown. The administration of magnesium in large amounts did not diminish the frequency of the attacks nor did large doses of potassium chloride over three months increase the frequency of attacks.

Predisposing and Preventive Factors. In considering this aspect of the problem of the epileptic seizure it is necessary to state clearly that we already know of a certain number of factors which will produce epileptiform attacks. Some of these are quite foreign to the economy of the organism, *e.g.*, metrazol, and will be discussed in the section dealing with experimental convulsions. Other factors, however, may come into operation during the day to day functioning of the organism and are therefore to be considered as predisposing factors. From the fact that several of these agents seem competent to produce a convulsive reaction, it appears reasonable to consider that the epileptic seizure is a relatively nonspecific type of response.

It has long been known that oxygen lack is a factor of considerable importance in the production of the convulsive reaction. The earlier reports originated from observations made upon animals which were being bled, or in which cerebral anemia was produced in other ways such as rotating (Muskens, 1928). With advancing knowledge concerning the control of low oxygen tension atmospheres, study of the action of this factor in producing the epileptiform reaction has been rendered considerably more practical. Lennox (1928) has shown that seizures may be produced in persons who have frequent petit mal attacks by having them breathe air deficient in oxygen. In a later (1929) publication it was, however, emphasized that anoxemia did not elicit attacks in all patients who were suffering from epileptic seizures. It is clear that, if anoxemia is to be considered a factor in the elicitation of the convulsive reaction in the epileptic person under ordinary circumstances as distinctive from the experimental situations just described, it will be necessary to demonstrate that actual reduction of oxygen consumption by the brain or part of the brain does occur. Lennox and Gibbs (1936) studied the oxygen saturation and carbon dioxide content of the blood in 88 persons suffering from epilepsy. They found the average arterial saturation was 93.4 per cent and consider that this slight degree of anoxemia is quite insufficient to elicit seizures though it might be regarded as a contributory factor. Means do not exist at present to permit of the estimation of the oxidation rate of distinct parts of the central nervous system in the living subject. Estimation of the oxygen consumption of the brain by means of arterial and jugular punctures, even when controlled by means of records of the blood flow, do not permit more than an approximation which is, in turn, limited to the precise time that the samples were taken.

Further evidence that anoxemia might be a regularly occurring factor in the production of the convulsive attack in the epileptic individual has been offered by Lennox and Cobb (1929) who report that breathing pure oxygen may abort an impending seizure and that the amount of hyperventilation necessary to produce a seizure is definitely greater when the patient breathes atmospheric air than when he breathes a low oxygen tension atmosphere. More recently Gibbs, Lennox and Gibbs (1940) have reported that the arterial and internal jugular CO_2 was abnormally high in patients subject to grand mal seizures and abnormally low in patients experiencing petit mal attacks. They found that these fluctuations preceded the actual attacks and suggested they might be linked up to the broader problem of the acid-base equilibrium. Nims *et al.* (1940) have reported that, following upon hyperventilation, there is a greater and more prolonged drop in CO_2 content of the internal jugular blood than in the normal subject.

The discovery that abnormalities of the electroencephalogram could be associated with the occurrence of epileptic attacks (Kornmüller, 1935; Gibbs *et al.*, 1936) has yielded further information concerning the facilitation and control of seizures. The occurrence of a three a second wave and spike pattern in association with petit mal attacks has been confirmed by several workers. This activity is much reduced by breathing an atmosphere having a high CO_2 content. Insulin tended to increase the frequency of appearance of the abnormal pattern while the addition of dextrose decreased it (Gibbs, Gibbs and Lennox, 1938).

Interest in the water metabolism of persons suffering from epileptic convulsions took origin from the observations of Rowntree (1922) that animals in which a state of "water intoxication" had been created by means of the forced administration of large amounts of fluid tended to show convulsive attacks. Based in part on this observation and in part on the fact that areas of atrophy and accumulation of cerebrospinal fluid are not infrequently found in epilepsy, Fay (1929) advanced what he termed a mechanical theory of epilepsy. He suggests that the subarachnoid villi play a most important part in the absorption of cerebrospinal fluid. These villi are subject to the vicissitudes of any other tissue; they are prone to the same possibilities of congenital malformation and are possibly as open to infections. In particular, they tend to suffer from the effects of birth injury and hemorrhage at birth, which Fay considers to be more often present than is realized. Either at once or when, with the increasing growth of the brain, extra demands are put on them they begin to show progressive failure. This failure permits the accumulation of large amounts of cerebrospinal fluid over the cortex. This supracortical edema stretches the arachnoid attachments to the cortex and the occurrence of the frequent small changes in cerebrospinal fluid pressure produce a subliminal stimulation which predisposes the cortex to discharges. As a further link in this chain of events he postulates the occurrence of a circulatory disturbance such as a transitory cerebral anemia. The result of this is to produce increased intracranial pressure with a further transudation of fluid which may act as the factor precipitating a discharge from the already sensitized cortex.

The diet which is based upon these views is naturally one in which the water content is markedly reduced. The reduction should be to the level of eight to twenty ounces per day. In order to have the patient carry this out, considerable intelligence and cooperation are necessary. Of his original 17 cases, 6 had to be discontinued owing to lack of cooperation. For the rest he states that he has not found it difficult, in the small number of cases he studied under dehydration, to alter the character of the attacks and to remove the generalized seizures and unconscious phase. In cases of slight seizures the petit mal attacks persisted in spite of the most rigorous fluid limitation, even to six and a half ounces (200 c.c.). Since then (1929) the value of this procedure has been investigated by several workers. Their reports in the majority of cases have been unfavorable. Cameron (1931) carried out the treatment in a series of 12 typical institutional epileptics. He also experimented with the effects of pushing fluids both before dehydration and afterward. The results throughout were conflicting and no definite effects upon the frequency of the fits or upon the patient's disposition were obtained either by dehydration or by pushing fluids. The patient's general health was found to be affected; there was often severe initial loss of weight; and when water restriction was pushed there was always the danger of the occurrence of acidotic and uremic states.

Doolittle (1931), reporting upon the effects of the ketogenic diet combined with water restriction, states that in only one of 26 cases in which a modified ketogenic therapy combined with water restriction was carried out could he feel that the treatment was successful. Six others showed a marked improvement as to the occurrence of grand mal seizures. The improvement in two others was slight. In the remainder of the cases there was either no improvement or an actual increase in the number of seizures. He noted also that when the patients could not be controlled and were returned to unlimited fluid intakes, though they usually took large quantities of fluids in the first twenty-four hours, there was no increase in the number of fits. Finally he noted the danger of collapse and hyperthermia from over-dehydration.

Fetterman and Kumin (1933) carried out dehydration on a group of 21 outpatient epileptics, 9 of whom were hospitalized during the period of therapy. A check upon the adherence to diet was made by estimating the specific gravity of the urine. In addition, a diet yielding an acid ash was given to most of them.

In the case of the hospitalized patients after a period of dehydration, fluids were given to the limit of the patient's desire; they report that their results were essentially negative. Dehydration had little effect upon the frequency of the seizures and hydration did little to increase the number.

Wilson and Limberger (1933), who studied the effects of hydration and dehydration at the Pennsylvania Epileptic Hospital and Colony Farm over a period of years, made a similar report. They state that they consider dehydration of little value used by itself, but if combined with other methods it may be of service. They found that status may develop even during extreme dehydration. The giving of large amounts of fluids after dehydration did not provoke bursts of fits with regularity of frequency.

Other workers, notably McQuarrie (1929) and Clegg and Thorpe (1935), have considered that the pushing of fluids by mouth, especially if excretion is blocked by means of pitressin, tends to increase the frequency of seizures. It is clear that the therapeutic test has not sufficient precision to afford a definite statement regarding the part played by hydration in the production of convulsive attacks in the human subject. Further experience with the method has, however, shown that the attainment of the severe degrees of hydration which have been recommended is rarely practical.

Fay's "mechanical theory" has also been attacked on experimental and theoretical grounds. It is fairly generally agreed that "wet brain" is frequently found at autopsy and supracortical collections of fluid are frequently reported at operations. It was pointed out, however, by Cobb (1932) that Fay's theory would not actually account for these collections of fluid and for the cortical atrophy which usually accompanies them. If the choroid plexuses are the main source of production of the cerebrospinal fluid and the pacchionian bodies are the main channels of absorption, it stands to reason that there must be a pressure gradient between the two with the regions of higher pressure inside the ventricles and the regions of lower pressure over the cortex. Consequently, the hydrocephalus should be an internal one and under Fay's hypothesis the cortex would be pressed up against the dura. Cobb's belief is that atrophy of the cerebral cortex is a primary lesion and that the accumulations of cerebrospinal fluid are secondary and space filling.

Doubt has been expressed as to whether there is actually an increase in the cerebrospinal fluid pressure in epileptics. Probably the most trenchant criticism of Fay's theory has been that as yet there has been no adequate demonstration that the cerebrospinal fluid pressure is either increased by drinking water or decreased by dehydration. Cobb quotes Lennox and Fremont-Smith as having failed to find any appreciable difference between the pressures of two patients who were subjected to periods of forced fluid intakes and to periods of dehydration.

Fremont-Smith and Merritt (1933) obtained similar results in a larger group of patients. Some years earlier in the course of studies upon the effects of forced drainage, Kubie (1926) had noted that during animal experimentation the amount of cerebrospinal fluid excreted showed a slight tendency to increase when the fluid was given by mouth. He attributed this to the "lag" which occurred before the kidneys took up the task of excretion. Once they had begun to act the extra secretion of cerebrospinal secretion died down.

More recent work on water metabolism in epileptics by Stone and Chur (1937) has failed to show that under ordinary circumstances the water metabolism reveals any significant departure from normal.

Reference was made earlier to the possibility that a disturbance in the acid-base relationship may exist in persons who suffer from epileptic convulsions. While this is still under investigation it can be said that alkalosis tends to promote seizures while acidosis tends to prevent their appearance (Lennox and Cobb, 1929). Rosett (1924) and Foerster (1925) have described the elicitation of convulsions in persons suffering from epilepsy by means of hyperventilation. The factor of importance in this procedure is the lowering of the blood CO_2 and the production of a relative alkalosis. Under such circumstances seizures can be produced in some epileptics. The percentage is variously reported as ranging from 19 to 60. On the other hand, breathing atmospheres having a high CO_2 content has been found to reduce the frequency of petit mal attacks. Attempts to reduce these experimental results to practical application as in the ketogenic diet introduced by Peterman (1928) have met with only limited success.

The cerebral vasomotor activity in epilepsy constitutes a further line of investigation. It originated with observations to the effect that facial pallor might accompany a convulsive attack. Later animal experiments showed that the vessels of the meninges could be caused to constrict by stimulation of the cervical sympathetic. The next step was the observation during operation that cerebral vasoconstriction might occur in association with a convulsive attack. With greater refinements of research technique certain further advances have been made. It has been shown that in many instances areas of destruction can be demonstrated in the brain tissue of epileptics which are very similar to what one finds in the brains of individuals in whom a profound disturbance of circulation has occurred (Spielmeyer and Foerster, 1926). Investigations of the rate of blood flow through the internal jugular vein, both preceding and during petit mal and grand mal seizures in the human subject, have been made (Gibbs, Lennox and Gibbs, 1934). These have shown that there is no increase in blood flow preceding an attack, but a great increase occurs during severe convulsions. The authors consider that these changes which occur in the blood flow are the result, rather than the cause, of the seizures. Finally, by means of combining extensive direct observation of the brain at operation, together with electrical stimulation of the suspected area and subsequent histological examination, Penfield and Humphreys (1940) have been able to describe aganglionic meningocerebral cicatrices. At the advancing edges of these are areas of focal destruction which are similar to those found as a result of local vascular occlusion. Electrical stimulation of these areas may produce the patient's habitual seizure, and it is from these areas that the typical electroencephalographic pattern may be picked up. He suggests that the arteries of these cicatrices undergo periodic constriction and that this may be the cause of the slowly advancing atrophy. However, the vascular change which accompanies an actual convulsive reaction is a dilatation of the vessels of that part of the cortex which is involved in the seizure.

The possibility that the epileptic seizure may be initiated at the higher functional levels is suggested by numerous observations. Reports have appeared at intervals concerning single patients who have developed seizures in response to loud noises or more specific fear stimuli (Fremont-Smith, 1934). It is frequently observed, moreover, that patients who had been having frequent seizures at home cease their attacks for a time after admission to hospital irrespective of whether they are on medication. At a later date the seizures usually return though their regime may not have been changed in the slightest. This aspect of the causation of the epileptic convulsion remains a matter of observation rather than of experiment.

The part played by inheritance and structural changes in the production of epileptic attacks will be considered in the appropriate sections.

Experimental Epileptiform Seizures. The production of seizures by experimental means has been of considerable value in the study of the mechanism of the convulsive attack and in the development of measures to control it. Reference has been made above to the early observations upon the effects of cerebral anemia. This method of eliciting the convulsive reaction has now given place to such agents as electrical stimulation and chemicals such as thujone, monobromated camphor and metrazol.

The actual form of the seizures produced by the various agents has not been extensively investigated. Cobb (1924) has studied the electromyograms of rabbits during thujone convulsions. He found that the records were tetanic in character, resembling those described earlier as having been noted in the human subject during an epileptic seizure. Strauss and Landis (1938) report investigations on the type of seizure produced by metrazol. They made use of the high speed camera and electromyograms and found that the metrazol convulsion consists of three phases — first clonic, then tonic and finally a second clonic. They consider that the ordinary epileptic seizure corresponds to the tonic and second clonic phases produced by metrazol. The electromyogram during the tonic phase resembled that found in decerebrate rigidity.

Certain aspects of the activity of the vascular apparatus during the convulsive attack have been investigated further by means of studying this activity during experimentally produced seizures. The findings of Gibbs, Lennox and Gibbs (1934) to the effect that cerebral blood flow as measured in the internal jugular vein is increased during a convulsion in the human subject has been considered under the section on predisposing and preventive factors. By means of a thermocouple inserted into the left parietal cortex Gibbs (1933) has shown that the production of seizures in animals by means of picrotoxin, caffeine, oil of absinthium, camphorated oil or induction shock does not result in a general diminution of cerebral blood flow. Penfield, Santha and Cipriani (1939) have been able to make a rather more positive statement on this problem. They used direct electrical stimulation of the gray matter and recorded the changes in blood flow of the stimulated area. This was done both in animals and in a few patients on whom operation was being performed for the relief of focal seizures. In both groups the appearance of a seizure was followed in a few seconds by an increase in blood flow in the area which had been stimulated. The increase did not involve the whole brain, and therefore the authors are inclined to attribute it to increased ganglionic activity rather than to general changes in circulation.

The use of the experimental seizure has served to throw some light upon the question of the relationship which exists between the various functional areas of the brain and certain aspects of the seizure. It has been shown, for example, that removal of the motor cortex prevented the development of clonic convulsive movements in the contralateral side. However, this effect is only transitory, and if sufficient time is allowed to permit of recovery from the operation clonic convulsions can be evoked again (Pike and Elsberg, 1925). It is generally agreed that the tonic phase is dependent upon subcortical structures.

Control of Seizures. Certain factors which tend to prevent the appearance of epileptiform seizures have already been described during consideration of naturally occurring preventive and facilitative agents. It is proposed to discuss, in the present section, mainly the experimental work done on those agents which do not exist under ordinary circumstances within the economy of the organism.

As demonstrated by Foerster (1925), hyperventilation will elicit seizures in a certain percentage of individuals who are prone to have such attacks. Lennox and Behnke (1936) report that the ease with which such attacks can be elicited is greatly reduced if the subject is made to hyperventilate in an atmosphere of increased oxygen tension. Similarly Fog and Schmidt (1931) have shown that, if the atmosphere in which hyperventilation is carried out contains a high CO_2 content, the tendency to develop seizures is again reduced.

The experimental production of seizures in animals has been particularly useful in studying the value of chemical agents as a means of control of seizures in epileptics. Bromides have a long history (Wortis, 1933) of use in this respect. It has been shown that they reduce the electrical excitability of the cortex in dogs and tend to reduce the seizures ordinarily produced by camphor or cocaine. Keith (1933) has reported that acids injected in an animal which was given thujone tended to reduce the likelihood of seizures. The acids used were acetic, lactic, citric and hydrochloric. This is of interest in view of the present work being carried out on the question of the acid base balance in epilepsy. He also reported that epinephrine, pituitrin S and pitressin greatly augmented the convulsant action of thujone. The reason for this is still unknown.

An outstanding example of the utility of this experimental approach consists in the demonstration of the value of dilantin as a means of controlling seizures (Merritt and Putnam, 1938). Recently it has been shown that curare (Bennett, 1940) and erythroidin (Rosen, Zeigler and Cominole, 1940; Rosen, Cameron and Zeigler, 1940) can be used as a means to reduce the severity of the seizure produced by metrazol to the point where fractures are no longer likely to occur.

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CHAPTER XIII

ELECTRICAL PHENOMENA

With the growth of knowledge concerning electricity and more particularly with the development of means of measuring small changes in potential there has come a rapidly increasing series of investigations concerning the electrical phenomena of the organism. From the behavioral point of view the major interest has been devoted to the psychogalvanic reflex, action currents, chronaxie and more recently to the changes in potential associated with cerebral activity. The electrocardiograph has afforded comparatively little data of importance from the behavioral point of view. The contributions from this field have been mainly a few studies of the effects of emotional disturbance and particularly startle upon the electrocardiogram. Some use has also been made of this technique to check upon possible cardiac damage resulting from insulin and metrazol therapy (de Chatel and Palisa, 1935; Pellers, 1938).

Psychogalvanic Reflex. This name was given by Veraguth (1906) to the fluctuations in electrical resistance of the body which may accompany higher level activities. The term is commonly used to cover both fluctuations in resistance to the passage of a current of external origin and also to changes in the actual e. m. f. of the organism. Prior to Veraguth's systematic investigations a number of isolated reports had been made over a period of several decades. Some of these earlier workers had already announced concepts concerning the psychogalvanic phenomena which were early incorporated into our thinking and have in some instances produced a good deal of confusion. Vigouroux (1888) suggested that fluctuations in the electrical resistance of the organism were to be correlated with changes in the vasomotor system. Féré (1888) reported that fluctuations in the resistance could be demonstrated as occurring in relation to emotional reaction and also showed that there was a relationship between these electrical phenomena and changes in volume as recorded by the plethysmograph. These reports concerning the association between the psychogalvanic reflex and emotional reactions led to great interest in this field. In particular, impetus was given by the utilization of this method in connection with the word association studies initiated by Jung in the early part of this century.

Since that time numerous investigations have been carried out concerning the light which this method might throw not only upon emotional reactions but also upon tension states, conation, malingering, unconscious activities and sleep.

There is no general agreement as to the various links in the psychogalvanic reflex. Several final common pathways have been suggested. Most attention has been devoted to the following possibilities — that the reaction is dependent upon the sweat glands; that it is dependent upon vasomotor changes; that it arises from muscular tension; and that it is a polarization phenomenon. There is a more general agreement that, whatever the last link in the chain may be, the integrity of the autonomic nervous system is necessary for the existence of the psychogalvanic reflex. Müller (1913) has shown that after severance of the nerves to the part there is a resulting abolition of the reflex. Schilf and Schuberth (1922) have shown that, if the central nervous system above the level of the medulla is destroyed, the reflex can still be obtained. These workers have also reported that, when the frog is divided into two portions connected only by the sympathetic fibers, stimulation of the front portion will produce a galvanic response in the rear portion. Richter (1925) has demonstrated that the reflex was unilaterally lost in the case of a man suffering from paralysis of one sympathetic trunk.

The evidence that the reflex is dependent upon the activity of the sweat glands is not so certain; experiments in which atropine has been used to inhibit their activity have yielded rather contradictory results. Walker (1919) investigated possible increased sweating during emotional disturbances as recorded by the psychogalvanometer by means of calcium chloride capsules, but failed to reveal any increase.

Attempts to correlate the reflex with vasomotor changes have shown that the reflex coincides with decrease in volume of the part. This decrease in volume is possibly, but not necessarily, to be correlated with vasoconstriction. The temporal relation between volume and electrical changes are widely varying (Darrow, 1929). It has also been shown that the skin resistance is correlated to some degree with temperature changes both in the subject and in the electrodes should these be fluid (Westburgh, 1929). A rise in body temperature is associated with a decrease in resistance and a fall in temperature with a rise in resistance. This is especially interesting in connection with the work which has been done upon heat production in schizophrenia (Hoskins, 1932) and in connection with heat control (Cameron, 1934). It has been shown that in the schizophrenic taken as a group, heat production is less than in the normal, and it has also been shown that heat regulation in the early schizophrenic group exhibits an apparently compensatory action, achieved possibly through a greater activity of the sympathetic nervous system. In the course of this latter investigation it was also found that the temperature of the individual is subject to frequent change so that it was impossible to record the same temperature, even on a clinical thermometer, as long as the patient was sitting up; after having been in a recumbent position for half an hour to an hour fairly steady readings could be got. It was also found that if an individual had been walking about and, more particularly, if he had been doing manual work previous to the examination, his temperature would continue to rise for at least half an hour and would increase in some cases as much as 1° F. (Cameron, 1934).

Richter (1929), reviewing the physiological factors concerned in the reflex, states that the resistance depends principally on conditions arising in the skin and points out that the resistance drops to zero if a small puncture is made by a hypodermic needle before the electrode is applied. He believes that some of the discrepancy in the results of various workers may be due to a failure to realize that the skin resistance is lower and less fluctuating in the palms than on the backs of the hands. He finds that the resistance in the palms is primarily dependent on the activity of the sweat glands and quotes an impressive array of experimental evidence to support this. He found that the dorsal activity was very little dependent on the sweat glands, and that it was not controlled by nerve impulses but by local conditions such as the temperature of the blood and chemical substances in the blood. It was dependent principally upon the epithelial cells.

The earlier work on the psychogalvanic reflex undoubtedly suffered from a failure to differentiate between the types of reaction recorded by the apparatus. Changes in resistance may be caused by muscular movements, by alterations in the contact between the skin and the electrodes, and by deep respiratory movements. The alterations due to emotional disturbances can be distinguished from those due to muscular movements, and indeed from those due to most other stimuli, by the fact that the change in resistance does not occur until after a definite latent period or lag has occurred from the time that the stimulus was given. This lag is, on the average, about two seconds in duration. The reaction provoked may last for a considerable period up to a few minutes.

A further complicating factor has been the failure to realize that the resistance in different parts of the body and especially that of the palms as contrasted with the resistance of the skin on the backs of the hands varies very considerably. Richter states further that the resistance of the palms and of the backs of the hands changes independently.

A good deal of work has been done upon the problem of polarization which occurs during the examination of the reflex. Briefly, when a current is passed through living tissue an opposing current is set up so that the resistance of the skin appears to be higher than it actually is. McClendon and Hemingway (1930) have studied the phenomenon in some detail and suggest that the psychogalvanic reflex is due to a change in the polarization capacity of the plasma membranes lining the sweat glands in the skin. They further point out that the electrical capacity of the cell varies on being stimulated.

Further data concerning the mechanism of the psychogalvanic reflex have been provided by reports by Darrow (1937) and Schwartz (1937) to the effect that the reflex has cortical representation in the prefrontal region. The latter worker has shown that in cats the integrity of the major portion of area 6 is necessary for the elicitation of the reflex.

As indicated earlier, it was originally considered that the psychogalvanic reflex was an indicator of the occurrence of an emotional reaction. Considerable interest was directed toward the possibility of using this phenomenon as a means of analyzing different forms of emotional reaction and in particular as a means of determining whether given situations had a significance for the patient which he was either unwilling or unable to report. For this reason it has been used in the so-called lie detection work and also in word association studies.

With regard to the analyses of different types of emotional responses the earlier hopes have been disappointed. It has not proved possible, for example, to distinguish between electrical skin reactions associated with pleasant and unpleasant emotional responses. Ruckmick (1938), however, considers that if the emotional responses are set in a scale in order of their cultural elaboration it is possible to say that the more primitive, *e.g.*, rage, are accompanied by a more marked psychogalvanic reflex than are the more highly evolved such as jealousy. Further he considers that the subject's statement as to the severity of the emotional reaction which he is experiencing is positively correlated with the degree of psychogalvanic response.

Even with this limited statement there is by no means general agreement. Landis (1934) reports that the psychogalvanic reflex must be considered in terms of the activity of the autonomic. Since the emotional reaction is largely integrated through this system it is reasonable to anticipate that a psychogalvanic response will occur in association with an emotional reaction. However, since the autonomic subserves functions other than that of integrating the emotional reaction, one may find a psychogalvanic response occurring in the absence of an emotional reaction.

Interest also attaches to attempts which have been made to study the correlation of the reflex with other aspects of behavior. Abramowski (1913) and Aveling (1929) have reported that a correlation exists between volition and conation and the reflex. The response consisted in a decrease of resistance. It is of interest to note that Aveling states that his subjects reported an experience of alertness which correlated with the appearance of the reflex. Abel (1930) found little confirmation for the assertion that the reflex could be considered as related to conation. Her subjects most commonly reported a sudden check in comprehension or in the solution of simple problems. It is nevertheless possible that these various reports may be reconciled. It is already known that tension increases during conation and also during the performance of difficult tasks. It is also known (Landis and Hunt, 1935) that the galvanic reflex commonly accompanies states of tension. Richter (1929) has found that electrical resistance is increased during sleep and Ruckmick (1938) has reported that during fatigue the resistance is decreased. Subsequent disagreement concerning these findings with reference to sleep seems likely to be capable of solution on the basis of a more precise statement as to the kind of sleep which was being investigated. Our growing knowledge concerning sleep has served to bring out the fact that under the term sleep may be gathered quite varied patterns of awareness, restlessness and tension.

A great deal of work has been done upon the phenomena of the psychogalvanic reflex in persons suffering from psychopathic states. Early workers hoped that the reflex might provide a means of more critical diagnosis as well as a tool which would assist in the analysis of these states. Such hopes have not been altogether realized. The difficulties encountered may be summarized as follows: technical difficulties ascribable to the apparatus and in particular to the electrodes, difficulties inherent in the problem of devising a standard stimulus which will have the same value from one individual to the other and in the same individual on repetition, difficulties in determining whether a given response is attributable to the stimulus or to coincidental happenings and, finally, the difficulty in obtaining clear-cut and generally acceptable representatives of any given psychopathic group.

In consequence of these difficulties most agreement is obtained when psychopathic behavior as a whole is contrasted with normal behavior or when the larger, better defined psychopathic groups are compared with each other. It can be said that the readings obtained from psychopathic patients are more variable than those obtained from normal control groups and that, in general, as the patient improves the variability of the readings becomes less. Richter (1928) found this to be particularly true of schizophrenia. The catatonic group has been reported by Syz and Kinder (1928) to show a high initial resistance with few spontaneous waves. There is fair agreement on this point. It has not been possible to make any clear-cut statement regarding the psychoneurotic reaction types. McCowan ascribes this difficulty to the probability that these reaction types are clinical syndromes rather than true entities. He noted that the hysterical group tended to show relatively little reactivity while that of the group characterized by anxiety showed many more reactions. These findings are of interest in view of the data reported by Lockwood (1932). She investigated the correlation between the psychogalvanic reflex and the hyperglycemic reflex in patients suffering from mood disorder. In those cases, in which there was no sustained hyperglycemia and in which the index was zero, the number of galvanic responses was normal or decreased. She pointed out that these negative findings were obtained even in cases in which there was clinical evidence of agitation and apprehension and believes that there is an interesting parallel between these findings and those of Golla (1921) and McCowan (1926) in that the enaction of emotional scenes and the adoption of emotional attitudes in normals and hysterics do not produce a reflex. When the hyperglycemic index was high she found that there was an increase in psychogalvanic activity and that the increase in the index and the reflex was not associated with any particular mental reaction type but with the degree of emotional tension shown by the subject.

Ödegaard (1930, 1932) has advanced the use of the psychogalvanic reflex somewhat further by devising a technique for the study not of the individual response to a given stimulus but of what he terms the general vegetative-emotional reactivity. The stimulus consists of a series of words or questions and the response is a psychogalvanic curve. These curves were analyzed from the point of view of the direction of deflection, from the point of view of the amount of deflection and from the point of view of the occurrence of fluctuations in the absence of stimulus.

The findings which he obtained by this method have corroborated those already acquired. He showed that there is more instability of response in the psychopathic group than in the normal and also that this tends to diminish as the patient recovers. In addition he reports that the more serious the condition the more atypical the psychogalvanic curve. The depressive patients show the most atypical reactivity when anxiety or agitation is present and, similarly, the schizophrenic curves are most atypical when emotional factors are marked. They are also atypical in catatonic and deteriorated patients. The greatest decrease in reactivity was found in the organic and schizophrenic patients.

Chronaxie. The technique employed in determining this phenomenon has not yet been applied at all extensively to the field of abnormal human behavior. It is known that on galvanic stimulation of a nerve the muscle supplied will, provided the stimulus is adequate, undergo contraction both at the make and break of the circuit. The adequacy of the current is dependent not only on its strength but also upon its duration. The shorter the duration of the current the stronger it must be in order to elicit a contraction. The chronaxie of a given nerve is accordingly defined as follows. First the minimum current which will elicit a contraction regardless of duration is established. This is termed the rheobase. The chronaxie of that nerve is then stated to be the shortest duration of time over which a current of twice the rheobase must act before a contraction is elicited (Lapique, 1926).

While most of the work on this phenomenon has been carried out with reference to problems of nerve physiology, some investigations have been undertaken concerning the chronaxie properties of nerves involved in certain aspects of human behavior. Wechsler and Freeman (1929, 1932) have studied the relationship between the chronaxie and the reaction time. The chronaxie taken was that obtained from the motor part of the biceps muscle of the arm used in the reaction time. A correlation of + 0.84 was obtained between the reaction time and the chronaxie. Studies of considerable interest have been made concerning chronaxie and the elicitation of a conditioned reflex (Chauchard *et al.*, 1937). These authors have shown that there is a diminution of the chronaxie both at the periphery and in the motor zones of the cortex during the elicitation of a conditioned reflex.

In the field of abnormal human behavior this procedure has been confined for the most part to the study of catatonia. Bourguigon and deJong (1928) investigated the chronaxie in cats in which experimental catatonia had been produced by means of bulbocapnine.

Last and Ström Olsen (1936) report that their investigation of seven catatonic human subjects showed that the chronaxie throughout the whole body was rendered much more variable than normal and that in addition most of the values were considerably increased. The picture was quite different from that found in Parkinsonian states. They suggest that these findings may be ascribed to secondary changes in excitability consequent upon the prolonged maintenance of catatonic postures. Weisz *et al.* (1937) have studied the effects of repeated stimulation upon the intensity of the current and upon the chronaxie. Their investigations were carried out upon normal subjects, upon catatonics, upon non-catatonic schizophrenics and upon patients suffering from mental disorders other than schizophrenia. They found that for all groups save the catatonic there was a fairly consistent drop in intensity and chronaxie upon repeated stimulation. In the catatonic group there was also a tendency to a decrease in intensity and chronaxie but in both instances this was significantly less than in the other groups.

Electroencephalogram. Further advances in our knowledge of human behavior have been made through the study of brain potentials. Since the latter part of the nineteenth century it has been known that electrical changes accompanied the activity of cerebral tissue. The earlier work, however, was carried out almost exclusively in animals and with crude apparatus capable of only limited amplification.

The recent extensive development of this field dates from Berger's (1929) report concerning his investigations of the electrical activity of the human brain. This report was especially important since Berger was able to announce that it was possible to study changes in potential without opening the skull. He stated that comparison between records taken in this way and records taken through trephine openings showed that the method whereby records were made over the unopened skull afforded a reasonably accurate picture of what was occurring in the actual brain tissues.

Though this ability to record the electrical changes of the brain represents an important advance, certain limitations of this method must be recognized before consideration is given to the various applications. The most serious limitation is one which is well brought out by Adrian (1936). This consists in the fact that the record which we are able to obtain is one of numerous simultaneous activities. Adrian compares the complexity of brain wave record with the simplicity of electrocardiogram or that of the electrical activity of the single nerve fiber. Until some method can be worked out whereby we shall be able to study isolated activities in the brain our statements concerning the electrical activity of that organ must remain quite general.

At present we are able to describe the record of brain potentials in the following terms — the wave frequency. Two frequencies are at present under consideration. The first and most extensively studied are waves having a frequency of 8 to 13 a second. These are known as alpha waves. It was originally considered that they arose exclusively in the occipital cortex and that they were related in some way to vision. This was believed to be the case since it was found that, on opening the eyes and attempting actively to distinguish objects, the alpha waves disappeared. For this reason it was thought that these waves represented the resting pattern of the occipital cortex and that this was broken up when the visual cortex was thrown into action. Recent work (Rubin, 1938) indicates, however, that the alpha rhythm may arise from any point on the cortex. The second frequency is that ranging from 16 to 40 a second. These are known as the beta waves; they appear to originate in the anterior part of the cortex. In addition interest has been directed toward the large slow waves which are associated with sleep and with abnormal cerebral states. Finally, by means of the cathode ray oscillograph very high frequencies can be picked up. The relationship of these waves to human behavior has not yet been worked out. In addition to determining the presence or absence of the various frequencies a given record may be assessed in regard to the percentage of the time that the alpha frequency is present and also as to the general level of electrical activity.

Physiological Correlates. Before considering the relationship of the brain wave pattern to behavior it is desirable to clarify its correlation with certain happenings at the physiological level.

Exposure to low oxygen tensions produces an increase in amplitude of the waves and a decrease in the frequency (Berger, 1934; Gibbs and Davis, 1935). When confusion sets in with increasing anoxemia the regular pattern breaks up and the slow waves become dominant. Breathing of higher concentrations of oxygen has little effect upon the wave patterns. The relationship of variations in blood CO_2 to the pattern has been considered mainly in connection with epilepsy and will be discussed in the section upon the brain wave patterns in persons showing abnormal behavior. Lindsley and Rubenstein (1937) have shown that there is a high positive correlation between the rise in basal metabolic rate produced in the normal subject by thyroid administration and the increase in the frequency of the alpha rhythm. Hoagland (1936) has shown, in three normal subjects, that elevation of the temperature by means of diathermy produces an increase in the alpha frequency. This supplements the earlier reports of a decrease in the electrical activity of the cortex in animals following upon cooling.

Correlation with Normal Behavior. Considerable hope was expressed during the earlier stage of the present greatly increased interest in the electrical activity of the brain that this approach might afford us a means of investigating, in a detailed way, the activity of the higher level functions. This hope has not yet been fulfilled. For the most part we are able to correlate only massive changes in behavior with those in the brain wave pattern. Such a massive change is that from sleeping to waking, or a state of marked tension and excitation to that of relaxation. Jasper (1936) has shown in the cat and the normal human being that extreme excitation is associated with a loss of all rhythmic potentials; as this grows less there appear high frequency low amplitude waves which are at first irregular. With moderate relaxation the waves become regular, then as the organism passes into sleep the rhythms become slower and irregularities appear. In sleep the frequency is still further decreased; there is more irregularity and the amplitude is still greater.

Attempts to correlate the variations in brain wave pattern with introversion and extroversion have not met with noteworthy success. Saul, Davis and Davis (1937) have reported that patients in whom there is a high percentage of alpha waves tend to be passive, receptive and dependent, while those in whom alpha waves are present for only a small percentage of a given time are stated to be active and enterprising. The question naturally arises whether the latter are not more tense; and, since we know that tension disrupts the alpha pattern, it may be that these variations simply report degrees of tension. Some interest has been directed toward determining the amount of consistency shown by the brain potentials. Travis and Gottlober (1937) studied the records of eleven normal human subjects taken on five different days. They evaluate the records on the basis of the trains of waves present, stability of the base line and fluctuations in the frequency and amplitude. From these studies they state that the record of one individual can be distinguished from the other with consistency and that the pattern shown by that individual is reasonably stable from day to day.

Correlation with Abnormal Behavior. Probably the most definite relationship between abnormal behavior and variations in brain potential is that which has been worked out with reference to epilepsy. Berger (1931) reported the presence of large slow waves in a series of epileptic dements. It has subsequently been shown that these abnormalities are more marked when the patient shows continued disturbance in his behavior and more or less present when the patient is relatively well between his convulsive attacks. Gibbs, Lennox and Gibbs (1936) have reported that a 3 a second wave followed by a sharp deflection producing a spike in the record is consistently associated with petit mal epilepsy. This has been confirmed by numerous workers. The grand mal seizure is associated with the appearance of slow waves of great amplitude (Jasper, 1937). Owing to interference by muscle action currents it is difficult to follow the pattern during the entire seizure, but it appears that bursts of slow waves continue throughout. Following upon the convulsion there is marked depression of all electrical activity. The normal pattern gradually becomes restored as consciousness returns.

No characteristic pattern has been described as being associated with the major psychoses. Davis and Davis (1939) state that it is impossible to distinguish the pattern of the psychotic patient from that of the normal but that greater variability is likely to occur in the records of the former. This statement is supported in general by the findings of other workers in this field. When increased variability does occur in the schizophrenic patient and when that variability takes the form of the appearance of slow random waves, Hoagland, Cameron and Rubin (1937) have shown that progress under insulin treatment is accompanied by gradual disappearance of these irregular waves. Slight differences in the pattern of stuttering and normal individuals have been reported by Travis and Malamud (1937). These differences consist in a slow frequency in stutterers during non-stuttering speech and in a greater amplitude of the waves in stutterers. Since it is known that stutterers show considerably more tension than normal, it is of interest to note that Hoagland, Cameron and Rubin (1938) have been able to produce interruption of the pattern by large slow waves following upon emotional stimulation of both normal subjects and psychotic patients. They have devised a means of recording these variations quantitatively. This measure, termed the delta index, is based upon estimation of all variations of the base line which are of larger extent than alpha waves.

Action Currents. The work in this field is still in its early stages. The data, which are at present available, indicate that when the individual imagines himself carrying out a muscular action it is possible to demonstrate that there is an increase in neural discharge to the muscles which would be involved had the action been carried out in reality. Further, it has been shown that there is a positive correlation between the degree of tension from which an individual suffers and the frequency and intensity of the neural discharges to his skeletal muscles.

Jacobsen (1938) has done extensive work in this field. He has attempted to apply the principle that the production of relaxation through training will produce relief of tension to several abnormal psychobiological conditions such as the anxiety neuroses and mucous colitis. A final statement of the efficacy of this procedure is not yet possible.

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CHAPTER XIV

OXIDATIVE FUNCTIONS

THE adequacy with which oxidation is carried out is a matter of immense importance for the behavior of the organism. This fact has received general recognition only in the last two decades. Impetus was derived largely from the experiences of aviation in the first World War, the later attempts to develop stratosphere flying and the rapid extension of oxygen therapy.

It is proposed to consider in this section the relationship between behavior and the entire series of processes by means of which oxidation is carried out. This involves consideration both of the effects which variations in oxidation have on behavior and the influence which behavior may exert upon oxidation.

Effects of Behavior on Oxidation. The most outstanding situation in which behavior affects the oxidation rate is that in which muscular activity is increased. At present this has not acquired much significance in the psychiatric field, though it seems probable that at least part of the increase in the oxidation rate which has been reported in connection with emotional responses and the mood disorders may be due to this increase in muscular activity. Little progress has been made in regard to elucidating the relationship between different levels of thinking and the oxidation rate. It is frequently asserted that intense mental effort is not associated with any increase in the oxidation rate. Unfortunately we have no way of determining what constitutes varying degrees of intellectual effort.

Variations in behavior exert their greatest effects upon the oxidation rate when the facilitative functions are active. Tensional states, emotional reactions and mood responses exert an influence upon the oxidation rate. That influence is nearly always in the direction of an increase in the rate. Landis (1925) has reported that in extreme emotional shock in animals the basal metabolic rate may be lowered. In the pathological mood disorders the oxygen consumption is increased particularly when there is agitation. Variation in the oxygen consumption rate has been reported in connection with several reaction types. In these instances it is not clear, however, whether this increase is due to the reaction or is one of the causative factors. Accordingly these findings will be discussed in the section on the basal metabolic rate.

The acitivity of the respiratory cycle and behavior also find their closest relationship in the facilitative functions. This has already been referred to in the section dealing with these functions. In general it may be stated that in the most simple form of emotional response, namely the startle reaction, there is first an inhibition of the respiratory cycle; this is followed by an increase in depth and rate. The effects of the more highly differentiated emotional reactions upon the respiratory cycle are more difficult to evaluate. It has been suggested that, in the presence of a pleasant emotional response, there is a tendency for the respiratory cycle to slow, the reverse being the case when the emotional reaction is of an unpleasant nature.

As indicated in the earlier section, the study of the respiratory cycle has not afforded altogether clear-cut data concerning the emotional reaction. One explanation for this consists in the fact that the respiratory cycle is influenced not only by primary changes in blood gas concentrations as well as by emotional reactions but also by the necessity of subserving vocalization. While clearly it is possible to detect the effects of ordinary vocalization upon the respiratory cycle, sub-vocal articulatory movements occur quite frequently at times of tension and probably in persons suffering from hallucinations. This constitutes a form of interference in the respiratory cycle which cannot readily be differentiated from other variables affecting it (Golla and Antonovitch, 1929).

Effects of Oxidation Rate on Behavior. Interference with oxidation may occur at many points in the series of processes which take place between inhalation and actual utilization of oxygen in the cell. The special effects which interference at a particular level may exert upon behavior will be discussed later in this section. At present we wish to consider the general effects of undue decrease and undue increase of the oxygen utilization upon behavior.

The most extensive work upon this has been carried out in connection with variations in the amount of oxygen in the inspired air. From this it appears that the effects of reduction in the amount of oxygen in the inspired air vary to some extent, depending not only upon the amount of the reduction but also upon the speed of the reduction. Studies are available not only of the effects of short exposure to reduced oxygen tension, as in low oxygen tension chambers and airplane ascents, but also of the effects of residence at high altitudes.

The first results of acute exposure are usually in the direction of a mild exhilaration and increased sense of well-being. Precise evaluations of this increased feeling of competence by such means as reaction time tests and multiple choice experiments show that performance has actually become considerably more variable. The subject is apparently still able, by exerting an effort, to keep himself at a high level of performance, but this effort is not well sustained and variation in his ability to carry out the tests results. These effects are well brought out by exposure to 11.5 per cent O_2 or altitudes of 16,000 feet (McFarland and Dill, 1938), and it is generally advised that airplane pilots should make use of oxygen as soon as altitudes of 12,000 feet are reached.

If the individual is exposed for longer periods of time to these O_2 concentrations the errors which he makes in carrying out test procedures become more marked (Barach *et al.*, 1937). With exposure to still lower O_2 concentrations interference with judgment becomes more pronounced; there is impairment of recent memory and a tendency to perseveration is noted. There are numerous reports of workers either in low oxygen pressure chambers or at high altitudes whose observations have become short circuited into a continuous repetition of some one phase of their work (Barcroft, 1925). Emotional reactions are common. Considerable irritability and depression have been reported. Individuals of unstable make-up seem to be rather more readily affected, and indeed exposure to low oxygen tension has been suggested as a means of detecting emotional instability in persons who, under ordinary circumstances, appear to be normal. Even short exposure to low oxygen tension may be followed by irritability and concentration difficulties which persist for a few hours or even days after termination of the exposure.

When the exposure is more continuous, as in the occasional long term experiments in low pressure chambers or in living at considerable altitudes, much the same behavioral changes are noted. Barcroft (1925) reports that after two weeks of intensive scientific work at Cerro de Pasco (14,300 feet) the members of his expedition showed symptoms of a "tired mind." There was considerable increase in the number of errors made, inability to work rapidly and considerable irritability. He states that those who are permanently stationed at this height have to work for short periods interrupted by long rests. Indeed, should any work requiring special concentration be necessary, the individual usually finds that he must first plan on a rest period at lower altitudes. McFarland (1937), in reporting studies made over a three months' period at various stations in the Andes up to altitudes of 20,140 feet, states that there was considerable impairment in tests involving the quickness to recognize the meanings of words. There was also an increased tendency to perseverate, and impairment of recent memory was outstanding. Two observations are of special interest. The first is that the subject was rarely aware of these changes in himself; there was an almost complete lack of insight. The second is that, if a special effort was made, it was possible to bring the work up temporarily to a good standard. The psychobiological meaning of effort has never been adequately explored and this seems likely to furnish a good lead.

It is still uncertain whether the high incidence of functional disorders in airplane pilots during war stress is to be ascribed to frequent exposure to low O_2 tensions (Armstrong, 1936).

A certain amount of work has been carried out in connection with the effects of lowered oxygen tension upon patients suffering from psychoneuroses. McFarland and Barach (1937) report that such patients do not stand exposure to 12 and 10 per cent oxygen nearly so well as do normal subjects. They suggest that this fact should be considered in relation to the finding that animals, which have been put under emotional stress, do not stand low oxygen tension so well as animals which have not been excited. They also suggest that in the psychoneurotic individual subbreathing may be more frequent than in the normal group. Exposure to high oxygen concentrations (50 per cent) tended to raise the efficiency of the psychoneurotic group on psychological tests. The effects of exposure to excess oxygen in other groups showing abnormal behavior have not been well worked out. We have repeatedly observed that senile patients showing confusional states tend to demonstrate an accentuation of their symptoms together with increased apprehension and irritability if left in 65 per cent O_2 for more than two hours at a time. Barach (1935) has reported similar findings in the case of a patient suffering from chronic emphysema. He suggests that in such cases the patient had become adjusted to a lowered O_2 tension and the symptoms resulted from interference with that adjustment. Euphoria has been reported in normal individuals exposed to oxygen at pressures of from one to four atmospheres (Behnke *et al.*, 1935).

O_2 Transportation. Interference with adequate oxidation may occur at many points. Apart from actual deficiency of oxygen in the atmosphere there may be a failure of the respiratory apparatus itself. Such failure may occur as a consequence of paralysis as in Landry's disease. Under these circumstances mild delirium with increasing dullness may occur. The emphysema of old age may also, through the reduction in tidal air, produce a degree of anoxemia (Cameron *et al.*, 1940). Interference may take place at the point of transfer of oxygen from the lungs to the blood stream. This is seen in pneumonia and possibly in the senile individual. Robinson (1938) has suggested that there is some evidence that in the aged thickening of the structures interposed between the alveolar spaces and the blood stream may interfere with a free transfer of oxygen.

Clearly varying degrees of anoxia may be produced by reduction of the oxygen carrying power of the blood, such as occurs in carbon monoxide poisoning, the various types of anemia, as well as slowing of the circulation time. Further, a lack of sensitivity of the respiratory center has been suggested in certain types of abnormal behavior. The amount of work which has been done on these various possible causes of anoxia and their relation to behavior is still very inadequate.

Low Oxygen Tension Atmospheres. This field has been the most adequately explored from the experimental point of view, and the effects upon behavior of breathing such atmospheres have been already discussed in the section upon the general effects of anoxia.

Interference of Passage through Lungs. Practically no experimental work has been done upon the effects of this kind of interference upon behavior. As mentioned above, interference of this nature may occur in paralysis of the respiratory mechanism, reduction of efficiency of the mechanism as in emphysema, pleurisy and pneumonia, or through decreased permeability of the structures lying between the alveolar spaces and the capillaries, such as may occur in old age.

O_2 Carrying Power of Blood. Very little work has been done from the experimental point of view concerning the effects of prolonged anemia or carbon monoxide poisoning upon behavior. It is generally recognized that individuals suffering from anemia do not do themselves justice on intelligence tests. There is an inability to carry on sustained effort and the speed of response is also reduced. It is most important that more precise investigations should be carried out in this field, especially with reference to the effects of anemia upon retention and upon emotional stability. From the observational side little progress is being made. Numerous single case reports of abnormal behavior associated with pernicious anemia are available, though Osgood (1935), reviewing the field, was unable to demonstrate anything but an incidental relationship.

The situation with reference to carbon monoxide poisoning and behavior is somewhat similar. A rather small percentage of the total number of persons exposed to carbon monoxide are reported as showing persistent behavioral changes — confusion, disorientation, tendency to project and memory disturbances (Shillito, Drinker, Shaughnessy, 1936). Several authors (Kant, 1926; Ribbeling, 1929) have reported catatonic reactions following upon exposure to the gas. In this connection it is of interest to note how frequently the neurological sequelae take the form of choreic and Parkinsonian manifestations.

Considerably more work has been done upon that aspect of the oxygen carrying capacity of the blood which is dependent upon the speed of the circulation. The circulation time has been worked out in connection with several different types of abnormal behavior and by several different methods. Of the various methods, that which is based upon the intravenous injection of sodium cyanide is the most reliable. As introduced by Robb and Weiss (1933) the method consists in the injection of sodium cyanide into an anticubital vein. The end point consists in an inspiratory gasp which results from stimulation of the carotid sinus. The test is usually described as the arm to carotid sinus circulation time test. Considerable care must be taken to insure that the procedure is carried out in the basal condition and that in the psychobiological sense. As can be readily understood, the circulation time and the pulse rate show a significant negative correlation.

The most extensive work upon the relation of the circulation time to behavior has been done in connection with schizophrenia. This condition has been considered by many workers to be associated with a reduced oxygen utilization, and by others as showing an autonomic system which is characterised by delay and inadequacy in action. Freeman (1934) reported a careful study of the arm to carotid circulation time in schizophrenic patients and in normal individuals living under the same conditions. He found that the circulation time in the normal group was 21.9 seconds, and in the schizophrenic group it was 25.6 seconds. On being retested four months later, the patient group gave a mean basal circulation time of 27.9 seconds. He emphasized that the circulation time had a negative correlation with the pulse rate, and was little affected by the systolic blood pressure or the basal metabolic rate. Further investigations by this worker (1938) have shown that the circulation time in the schizophrenic group is characterized not only by a long circulation time but also by a greater variability than is found in the normal group. Further information in this field has been provided by Gottlieb (1939) who has worked with a group of schizophrenics who were in considerably earlier stages of their psychoses than were the patients reported by Freeman. The mean circulation time for early male schizophrenics is given by Gottlieb as 19.1 seconds. The circulation time for the female schizophrenic patients was rather shorter. This more rapid circulation time in the earlier stages of the reaction is particularly interesting in view of certain reports to the effect that the reactivity of the autonomic nervous system in the schizophrenic undergoes a progressive deterioration both in regard to the speed and intensity of reactivity and in regard to its uniformity of reaction. Gottlieb further reports a circulation time of 19.8 seconds for a manic depressive group in which there was little difference between the readings on the manic and depressive patients. He found that the circulation time tended to increase with repetition of attack. Finally he reports that the mean basal circulation time in 11 patients suffering from mild arteriosclerosis was 24.4 seconds.

Cameron *et al.* (1940), using Freeman's technique, have reported, in a study upon the oxygen utilization in the senium, that the mean circulation time in a group of patients suffering from the psychoses of the senium was 25.6 seconds. It has to be again emphasized that the correlation between the pulse rate and the circulation time is fairly high and that, unless every effort is made to secure basality, unreliable results will be obtained.

A further method of recording the blood flow has been worked out by Gibbs (1933). This consists in a thermoelectric needle which can be inserted into a suitable vessel. The tip is heated and variations in the speed of flow of the blood result in variations in the amount of heat lost. This in turn results in variations in the e. m. f. produced by the thermoelectric junction. This method has not yet been widely used. It has served to demonstrate, however, that experimental convulsions are not preceded by a diminution in the cerebral blood flow (Gibbs, 1933).

Respiratory Center. The last aspect of oxygen transportation to be considered is sensitivity of the respiratory center. Considerable work has been done by Golla (1929) in this field in connection with schizophrenia. He points out that the acid-base equilibrium of the organism is maintained by two mechanisms, the respiratory and the renal. Tests revealed the fact that the renal mechanism was not impaired, and it was suspected that it might be the respiratory that was involved. He and his co-workers undertook to test this, utilizing as their method the breathing of 2 per cent CO_2, the volume of the respirations being recorded on a smoked drum. The response of the normal organism is an increase in ventilation. Eighty-eight per cent of the schizophrenics showed a depressed excitability of the respiratory center. This finding was noted whether the patient was stuporous, restless and excited, or outwardly normal in his behavior.

We have ourselves noted, during the administration of CO_2 to mute and negativistic patients, that percentages of CO_2, which caused extreme acceleration of the respirations up to between fifty and sixty a minute in the investigator and assistants, would provoke respiratory rates of thirty a minute at the most in the subject.

To the ingestion of alkalies the response of the psychotics was indistinguishable from that of the normals save that in the latter the ensuing diminution of ventilation passes over to increased ventilation to deal with the excess of retained CO_2 left after the kidneys have excreted the surplus alkali at the end of approximately two hours. This reversal did not occur in the psychotic group.

Further evidence in favor of this theory of a shift of the acid-base equilibrium consists in Armstrong's (1929) work in the distribution of chlorine in the blood. In the normal organism the red blood cells have a buffering action in that they take up the acid chlorine ion, setting free sodium to combine with excess of carbon dioxide in the plasma. During sleep that activity of the respiratory mechanism which, as we have seen, is an important agent in the removal of surplus CO_2 is depressed, and consequently the amount of chlorine ion found in the red blood cells is increased. In the psychotic, on the other hand, Armstrong found that the situation was reversed since, Golla thinks, during the daytime the respiratory mechanism was in any case working at a reduced efficiency and it was necessary to call heavily on the buffering action of the red cells to deal with the acid produced by the muscular activity, and during the night the production of acid falls off and consequently the red cells do not have to carry so much of the burden.

Golla reserves judgment as to whether these changes in the acid-base equilibrium are to be regarded as causative of the psychotic condition or as coincidental. He points out, however, that disturbances in mental functions may be produced either by eliciting alkalosis or acidosis.

He also reserves his opinion as to whether or not this tendency to accumulate acid necessarily leads to a shift of the acid-base equilibrium of the tissues to the acid side. He points out that the tissues may suffer from surplus of the sodium anion and the accumulation of CO_2 represents an attempt to offset this.

It would naturally seem that informative results might be obtained from attempts to alter the acid-base equilibrium.

Interference with O_2 Utilization. Evidence that certain of the abnormal behavioral reactions are accompanied by a reduction in the utilization of oxygen is not yet complete. In part the difficulties are technical; in part they arise from inadequate selection of material. It seems probable, for example, that the oxygen consumption of the more chronic schizophrenic reactions is less than in the more acute cases. Reports from many workers still give very little indication as to whether their work has been with these more recent cases or with cases of longer duration.

Basal Metabolic Rate. The method which is most frequently employed to demonstrate whether or not there is a reduction in oxygen consumption is the estimation of the basal metabolic rate. This has the disadvantage of being a "blanket" measure. For example, no information can be obtained as to whether cerebral metabolism or metabolism of the testes is at variance with that of the whole organism. Moreover, it is becoming increasingly clear that the term basal is highly relative. There are variations in the metabolic rate even during such an apparently passive condition as sleep. Habituation to the procedure seems undoubtedly to play a considerable part in lowering the rate. It also seems possible that stay over a period of weeks or months in a situation in which there may be very little activity or stimulus, such as the chronic ward of a State hospital, tends gradually to lower the basal metabolic rate.

Schizophrenia. Most attention concerning oxygen consumption in abnormal behavioral reactions has been directed to the schizophrenic psychoses. Bornstein in 1908 found that there was a marked reduction in the metabolic rate in a small group of schizophrenic cases that he examined. Kraepelin (1919), among the physical findings of dementia praecox, cites a reduced metabolic rate. Farr (1924) examined 100 cases of mental disorder, 50 of whom were suffering from schizophrenia. He found that 37 per cent of these cases showed a rate that was − 10 per cent or lower and that 17 per cent showed a rate of + 10 per cent or higher. He accepted as generally agreed that rates with − 10 to + 10 per cent are to be considered as being within normal limits. Farr's cases were of short duration and showed little deterioration. He suggests that this affords evidence of endocrine imbalance in dementia praecox but points out that his cases have shown little improvement after the administration of thyroid and thyroxin. Inanition and physical inactivity were not shown to be important factors.

Walker (1924) carried out two hundred investigations on 44 cases of mental disorder, 30 of whom were cases of dementia praecox. Those investigations were carried out over a period of two years. He found that 50 per cent of the cases of dementia praecox had a basal metabolic rate of less than − 10 per cent. The remainder had a normal basal metabolic rate or one that was slightly in excess of this. The range of the subnormal cases extended from − 12 per cent to − 47 per cent with − 20 per cent as the average. Three cases of catatonic stupor were examined and found to have a definitely low rate. Walker thought that when the readings were higher this fact was due to the presence of disturbing factors as shown by the increased respiratory rate and increased amplitude of respirations. He was able to observe no clinical evidence of thyroid disturbance and, from this fact and from the fact that administration of thyroid did not appreciably affect the behavior of the patient, he concluded that the thyroid was not responsible for the primary defect. He felt rather that there was a diminution of all bodily functions. He suggested the use of diathermy as a means of raising the basal metabolic rate temporarily. Hoskins and Sleeper (1929) have collected 206 cases of schizophrenia in which the basal metabolic rate was estimated. In 47.9 per cent of these the basal rate was below 90 per cent. In 80 of their own cases the range was from 71 to 106 per cent with a mean value of 89.1 per cent. In a subsequent report, in which the facts of habituation to the surroundings were taken into consideration and in which a comparison was made between the oxygen consumption rates of schizophrenic patients and normal controls both habituated to the same surroundings, Hoskins states that the mean rate for the patient group was 86 per cent and that for the normal group was 93 per cent.

Manic Depressive. Farr (1924) reports that 24 per cent of 38 patients suffering from manic depressive reactions had basal metabolic readings of below 90 per cent, while 4 per cent were above 110 per cent. Walker (1924) reports 14 manic depressive cases in whom the readings fell within normal limits, as was found in the majority of Whitelaw's cases. Bowman and Fry (1925), who report 25 cases of mood disorders, state that both the depressive and the hypomanic cases tend toward low readings, but that this is not so marked as in the schizophrenic cases. They also studied 19 cases of psychopathic personality and found that 7 of these gave abnormally low readings, while 2 gave abnormally high readings. In their 13 cases of mental deficiency with and without psychosis, there was a tendency to plus readings. They also reported upon 15 cases of epilepsy and epileptic psychoses. In this group they found the readings to be within normal limits.

Epilepsy. Lennox and Wright (1928) report a group of 130 epileptics. They found that the average basal metabolic rate for the group was 3 per cent below normal; 11.5 per cent had rates below 85 per cent while 4.6 per cent had rates over 115 per cent. They did not find that there was any correlation between these low rates and poor nutrition or bodily deterioration. They also failed to find that the decreased oxidation tended to increase with the continuance of the disease.

In their investigation into the basal metabolic rate in mental disease, Bowman and Fry (1925) furnish data on 15 epileptics. They found a tendency toward low readings, there being 12 cases which showed a minus reading as contrasted with 3 which showed a plus reading.

Notkin (1930) has investigated the question in more detail.

He separated his material into groups which had had treatment and groups without treatment. The rates for a group of 50 untreated patients fell in the considerable majority of cases within normal limits. Phenobarbital and bromide were both found to increase the percentage of cases giving a low reading.

Damon (1932) has reported the basal metabolic findings in 350 cases. He also notes a tendency toward low readings and on the basis of 300 of his group states that the chances are two to one that the rates will be abnormally low rather than abnormally high. Neither the age of the patient nor the duration of the disease was found to be a factor. It was noted, however, that in a group of 50, in whom there had been a remission of seizures for a period of a year or over, the percentage of low readings was not so great as in the group having seizures.

Damon further analyzed his results by dividing his material into five groups on the basis of the frequency of their seizures. A well marked tendency toward an increase in the percentage of low readings with the increase in the frequency of the seizures is to be noted. Contrary to the findings of Notkin phenobarbital was not found to exert an influence upon the basal metabolic rates.

With these considerable variations in the rate of oxygen consumption and consequently heat production shown by the various reaction types, the question naturally arises as to what effect this may have upon the temperature of the organism. So far, data upon sufficiently large numbers of cases to be of much statistical value are not available on all the reaction types.

Blood Gases. The method of estimating the oxygen consumption rate by means of such a technique as the basal metabolism has encountered a good deal of criticism on the grounds already referred to, namely, that no information can be obtained as to the oxygen consumption rate of special parts of the organism. To meet this objection considerable work has been done upon the estimation of the amount of oxygen found in the arterial blood going to a region and the amount found in the venous return.

The interesting question, as to whether there is a decreased consumption of oxygen in schizophrenia, has naturally led to attempts to approach this problem by means of the blood gas technique. Investigations on extensive series of patients have been reported by Thompson *et al.* (1937) and Looney and Freeman (1938). Both are in agreement that the oxygen content was within normal limits. Thompson and his co-workers report that the CO_2 content is higher than normal while Looney and Freeman find it lower and less variable. It may be of significance that the first group of workers studied blood from the internal jugular while the latter group took their blood samples from the anticubital vein.

The oxygen and carbon dioxide content in the blood of individuals suffering from the psychoses of the senium have been investigated by Cameron *et al.* (1940). This study, in which the venous sample was taken from the internal jugular, showed that, while there was some decrease in the oxygen carrying power of the blood, the difference between the oxygen content of the arterial and the venous blood was the same as is found in normals. However, since the circulation time was greatly prolonged in these cases and consequently the blood was in contact with the cerebral tissues for longer periods than normal, it is suggested that the fact that the difference between the arterial and venous oxygen content is not greater may indicate a reduced utilization of oxygen by the tissues.

Clearly these various attempts to estimate the oxygen utilization are quite indirect. It is impossible to make any precise statement as to the oxygen utilization of the brain until one knows both the size of the particular brain and also the total amount of blood flowing through it in a given unit of time. Moreover, it seems clear from direct observation of the brain in life that the amount of blood flowing from a given area may vary independently of fluctuations in the total blood flow.

Attempts to study the *in vitro* oxygen consumption of pieces of brain tissue removed at operation (Elvidge and Reed, 1938) naturally have to contend with the fact that the skull is rarely opened for reasons arising from behavioral disorder alone but for an intercurrent condition which tends to complicate the results obtained from the *in vitro* study. Moreover, the oxidative activity of such pieces of tissue *in vitro* have to be reconsidered in the light of the possible vascular supply which was available *in vivo*.

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CHAPTER XV

BASIC METABOLIC ACTIVITIES

It is proposed to discuss in this section certain metabolic activities which are of fundamental importance for the functioning of the organism. These activities consist in the metabolism of the basic food constituents — carbohydrate, fat, protein and water — mineral metabolism and the maintenance of the *p*H. The activity of the vitamins will be discussed in a separate section.

It may be said at the outset that serious disturbance of any of these basal metabolic activities renders the maintenance of normal behavior impossible. The relationship between the degree of interference and the kind of behavioral disturbance is not unitary. The behavioral response is made up of both general and individual factors. For example, hypoglycemia, if pushed far enough, will produce in all persons drowsiness and later coma. The individual responses are, however, quite varied. During the progression toward coma some individuals may become impulsive, others euphoric; some may show increased rapport, others may exhibit an increased sexuality.

Carbohydrate Metabolism. The relationship of carbohydrate metabolism to behavior is of particular interest in view of the fact that the central nervous system depends almost exclusively upon this order of substances as a basis for its energy exchanges. Our information in this field falls into two categories: first, instances where disturbance of carbohydrate metabolism accompanies variation in behavior but does not appear to be causative of the behavior; and, secondly, instances where the disturbance in carbohydrate metabolism is primary and the variation in behavior is a resultant.

With increasing acquaintance with sugar metabolism and the growing perfection of the blood sugar tests a considerable growth of interest in carbohydrate metabolism in mental disorders has taken place. It has long been recognized that hyperglycemia and glycosuria occur in certain of the mental disorders and it has also been recognized that both may occur in the normal individual during periods of emotional stress, for example, among athletes and among spectators watching athletic contests (Cannon, 1925).

Before proceeding to discuss the work which has been done in this field it is well to have a clearly defined concept of the present status of our knowledge of blood sugar. Briefly, the level of sugar in the blood may be said to depend on the following factors: the rate of carbohydrate absorption (not the amount), the glycogenic and the glycolytic functions of the organism and the renal threshold (Mann, 1925) and, to a considerably less extent, upon the rate at which it is oxidized in the tissues. The normal fasting blood sugar is in the region of 0.1 per cent with a range of from 0.080 to 0.120 per cent. Of late years the figures have shown a tendency to be reduced as more accurate methods of blood sugar estimates have been introduced, and non-carbohydrate substances contributing to the reaction have been eliminated. The administration of carbohydrates, as when 50 to 100 grams of glucose are given during a glucose tolerance test, is followed by a rise in the level of the blood sugar to about 0.17 per cent. In the normal individual this falls to the fasting level within two hours. The presence of endocrine disturbances may cause marked irregularities to appear in the normal curve. Whenever, for example, there is a pancreatic deficiency the organism's capacity to utilize carbohydrate is interfered with and the curve of the blood sugar will show a long drawn out rise in response to the glucose tolerance test.

In exophthalmic goiter one also finds in the large majority of cases hyperglycemic curves. In hyperthyroidism the tolerance for sugar is, as a rule, increased (Devine, 1929).

In acromegaly one meets with a high fasting level, with a high maximum and a fairly rapid return to normal. Glycosuria also occurs in these conditions (Devine, 1929).

The action of adrenalin in producing hyperglycemia is well known and indeed has been used by us as a temporary emergency procedure in insulin shock.

Abnormal curves are accentuated in certain infections such as boils, carbuncles and sycosis.

The fall in the blood sugar curve during a sugar tolerance test has been shown not to be due to the removal of some of the sugar from the gastro-intestinal tract, for analysis of the sugar remaining in the tract some time after its ingestion may show a considerable percentage of the original amount. It can also be shown that the amount oxidized during the period is too small to account for the fall which is indeed due to the coming into action of the pancreatic secretion, insulin, which facilitates the storage of sugar in the form of glycogen, principally in the liver.

As was mentioned earlier, the renal threshold is a factor in the preservation of the blood sugar level. The renal threshold is usually estimated as about 0.17 per cent; above this figure sugar tends to leak through the kidneys. It is found, however, that when the blood sugar has been consistently raised over long periods of time, as in diabetes, the threshold may also rise.

The past several years have seen most considerable advances in the technique of blood sugar estimations, and the procedure in the same widely used tests as the Folin Wu is so familiar as not to require repetition.

Certain points, however, will bear further emphasis. First, it is advisable to use a colored glass standard in place of a fluid standard because the latter fades and, through the occurrence of technical error, is never exactly the same color in each preparation.

A second point worthy of more attention is that the blood should be examined as soon as possible after withdrawal, for after half an hour at room temperature glycolysis sets in and at the end of an hour the sugar may be diminished by 7 mgm. and by the end of four hours by 20 mgm. (Nicholson, 1930).

The introduction of the micro methods of blood sugar estimation, in which 0.1 c.c. of blood sugar is usually taken in place of 2 c.c., together with the fact that in the psychiatric field importance is laid upon relatively small variations in the blood sugar level, makes it necessary that estimations should be made of the technical error of the procedure used. The sources of this error, while possibly small, are numerous. Among them is that of sampling. The chances that the drop of blood taken will be completely representative of the blood sugar level of the venous blood stream are small, although of course the chances that it will vary to any considerable extent are also small. Theoretically, the values will fall into a curve of normal distribution. Sources of error, based upon the fact that repeated measurements of the same object tend to show small variations which also fall into a curve of normal distribution, will be found to arise in the various other stages in the procedure, such as weighing the quantities of the reagents and comparing the color of sugar solution with the color of the standard.

This technical error will vary with the procedure followed and with the apparatus used. It should be clearly understood that the technical error, provided the procedure followed and the apparatus used remain the same, is beyond the control of the technician, but allowance should be made for it in calculating the blood sugar levels. It should be understood also that the technical error is quite different in source from the accidental errors of the worker or from the general level of accuracy to which he usually attains.

Blood Sugar Changes Associated with Behavioral Reaction. The work of Cannon (1925) and his associates on the behavior of the organism during pain, hunger, fear and rage has served as a point of departure for much of the recent work on the relation between the blood sugar level and emotional disturbances.

Cannon found, on subjecting his animals, usually cats, to emotionally disturbing situations, such as tying them to holders or exposing them to the danger of attack by a dog, that among the sweeping bodily changes brought about there was, very constantly, a rise in blood sugar and in many cases an appearance of sugar in the urine.

He found that this rise in the blood sugar level also occurred after stimulation of the splanchnic nerve but that no rise occurred after removal of the adrenals. This, coupled with the observation that epinephrine could be detected in the blood during emotional excitement and that injection of epinephrine caused a rise in the blood sugar level, led him to hold that increased secretion of epinephrine due to stimulation of the sympathetic nervous system was the factor causative of the production of widespread changes in the body and among them elevation of the blood sugar level.

Discussing the utility of this rise in the blood sugar level he points out that all the changes produced by increased secretion of epinephrine are designed to increase the organism's efficiency either in escape or attack, the increased blood sugar offering a rapidly utilizable source of energy.

He further points out that the fear emotion and the anger emotion were likely in less sophisticated times to be followed by flight or by fighting.

While Cannon's views have been fairly widely accepted there still remains a good deal of contradictory evidence. It is to be noted, however, that a considerable number of the workers in this field have based their views as to the action of emotion on the carbohydrate metabolism upon the presence or absence of glycosuria. This has been repeatedly shown to be a poor guide to the blood sugar level, and it must be regarded as especially so in the case of emotional hyperglycemia where the rise in the blood sugar level may not exceed the renal threshold for sugar. Moreover, our knowledge as to variations in the renal threshold is still too scanty to enable us to make a statement in regard to the presence or absence of hyperglycemia without coincidental examination of the actual blood sugar level (McLean and de Wesselow, 1921).

Maranon, quoted by Bowman and Kasanin (1929), states that he found hyperglycemia in pilots before a flight and an increased hyperglycemia after it. Cannon and Fiske found that twelve of twenty-five members of the Harvard University football squad had sugar in the urine after an exciting contest. Smillie, quoted by Cannon, found that four of nine medical students had a glycosuria after a hard examination. This matter is also considered in the sections on the facilitative function.

Mood Disorders. In considering the conflicting results which are obtained concerning carbohydrate metabolism in the field of pathological mood disorders, we must keep before us the fact that there are definite points of difference between the pathological mood disorders and fluctuations in mood occurring in normal individuals. It is to be borne in mind that in many instances the pathological cases when finally brought to examination have been experiencing their abnormal mood for a considerable period of time and it may well be that their supplies of glycogen are exhausted or that their adrenal reserve has been lowered.

It is of interest in connection with the first point to note that

Craig (1927), in examining a series of depressed patients, found that the fasting blood sugar was definitely lower in those cases in which the depressive reaction was of longer duration and also that the cases of involutional melancholia, the average duration of which is well known to be greater than that of the recurrent depressions, showed a tendency toward a lower fasting blood sugar. Ephedrin has been found to have a capacity similar to adrenalin in that it produces a glycemic reaction. Appel and Palmer (1932) found that the rise in the blood sugar in a group of 10 manic depressive patients was definitely less than in the case of a control group. Osgood, quoted by Cannon, states that the adrenal glands are soon fatigued, fail to respond to repeated stimulation and seem incapable of prolonged action.

A second possible point of difference between the normal mood fluctuations and the pathological mood disorders is that there may well be a qualitative difference between them, and indeed the retrospective accounts of purely depressed patients, especially those in whom retardation was marked, lend some color to this belief.

Finally, it has long been recognized that in some of the more long drawn out depressive reactions the patient may fall into a rut of lamentation in which all the actions indicative of psychic pain may be gone through and in which the patient reports being tortured by his experiences but in which objective tests fail to reveal serious participation of the organism as a whole in the reaction as presented to the observer. Where this is the case there is little disturbance of the carbohydrate metabolism (McCowan and Quastel, 1931).

Bearing these limitations in mind it is not surprising to find that, when investigation has been limited to the fasting blood sugar, at all events in the case of the mood disorders, the findings have been conflicting. Bowman and Kasanin (1929) examined 148 cases of mood disturbance and found that the fasting blood sugar was within normal limits. They found too that there was no correlation between the height of the fasting blood sugar and the severity of the mood disturbance. Lorentz (1922) also found that the fasting blood sugars were within normal levels but it is to be noted that the levels in his depressed cases were lower than in the manic cases.

Mumford and Parkin (1923), in examining a series of cases, found that the fasting blood sugar tended to be raised in excitements. This tendency and the degree of elevation of the blood sugar level were more marked when the excitement was of recent origin. On following up certain of his cases he found that the level tended to drop gradually even when there was no alteration in the clinical picture. Where an exacerbation occurred, however, there was a rise in the fasting blood sugar. When the excitement abated, the blood sugar fell. From these observations he concluded that there was no evidence that the mechanism of sugar metabolism differed in the mentally disordered, and that the blood sugar of the excited persons behaved in much the same way as one might expect in the case of a normal person suddenly confronted with an intensely emotional situation.

Other Disorders. Studies of the fasting blood sugar levels in other forms of abnormal behavioral reaction have failed to show marked deviation from normal. Lennox (1927) carried out approximately 2,000 estimations on 275 epileptic patients without noting any consistent change which might be causative of the convulsions. Lorentz (1922), reporting on 52 cases of schizophrenia, states that the fasting level in the paranoid group averaged 0.13 per cent, the catatonic 0.12 per cent, the hebephrenic 0.11 per cent and the simple 0.108 per cent. With regard to the psychoneurotic group little agreement exists. We may, however, state that the majority of observers are at one in declaring that the variation from normal is not great. Looney (1924) reports that, while the fasting blood sugar for a group of hysterical patients was 84.5 mg. per cent, that of his controls was 89.9 mg. per cent. Similarly Nielson (1934) found that a group of neurotic individuals had an average fasting blood sugar of 85 mg. per cent and his control group (102) had a level of 88 mg. per cent.

Sugar Tolerance. Originally most attention was directed to a single blood sugar test, the fasting blood sugar usually being taken. Since it has been realized that the blood sugar level is constantly varying, more attention has been directed to the manner in which the organism deals with a dose of sugar. This has led to the production of sugar tolerance tests. In the earlier tests the sugar was often given in the form of a carbohydrate meal, but later it was realized that the rate of digestion entered as a variable in this form of procedure to an unduly large extent. A further factor in absorption, which has not received full attention, is that the movements of the gastrointestinal tract are of importance in facilitating absorption since they bring a larger absorption area into contact with the sugar solution. More work is required in emotional disorders in this connection in view of the evidence that in animals the production of strong emotion inhibits movements of the gastrointestinal tract (Cannon, 1925) and in view of the occasional reports of the same phenomenon from the psychiatric field.

The meal of carbohydrate containing substances has now been largely abandoned in favor of a dose of pure glucose by mouth. The administration of the glucose meal intravenously was abandoned early as producing a totally unphysiological situation.

The dose most usually given is 50 to 100 grams. While considerably larger doses of perhaps 400 grams do not raise the level of the blood sugar higher, the blood sugar curve tends to become wider. As considerable stress is laid upon the question of whether or not the curve returns to the fasting level in two hours, the smaller doses are invariably taken. A further precaution which may be taken is to vary the sugar dose with the weight of the individual. While this is possibly of no great importance in the average person it should be borne in mind in persons showing extremes of weight; 1.5 gms. of dextrose per kilo body weight is recommended by Lennox.

When attention is turned from the study of the fasting blood sugar to that of the sugar tolerance test considerably more unanimity is found. It is rather widely agreed that the sugar tolerance curve is abnormal in the abnormal reaction types, and of the abnormalities the most frequently found is increase in the time that the blood sugar level requires to return to the fasting level. From examination of normal subjects it has been shown that return to the fasting level is to be expected within two hours. In the psychotic, however, this is frequently considerably prolonged.

Mood Disorders. Of the recent work done on sugar tolerance the most interesting and suggestive is that of McCowan and Quastel (1931). Accepting the undue prolongation of the curve as the outstanding feature of the abnormal curves found in psychotics they elaborated an index, which they termed the hyperglycemic index. (*See* section on carbohydrate metabolism, Chapter X.)

They point out that this index has the advantage of being independent of the absolute magnitude of the fasting level and that it is dependent only upon changes in the actual quantities of glucose in the blood.

On applying the index clinically they found that it correlated well with the degree of emotional intensity shown by the subject. They found it of value in detecting patients who were endeavoring to minimize their true condition in order to obtain their discharge, and also in detecting those cases of emotional disorder in which there is a large "hysterical" element. Here, as in the psychogalvanic reflex, incoordination between the apparent mood disturbance displayed and the actual disturbance, as recorded by the tests, was noted. They emphasize, however, that note must be made of the emotional and physical condition at the actual time of the test, for the disturbances in the blood sugar metabolism do not occur because the patient is, *e.g.*, "a depression" but because he is depressed.

In the manic phase a low index was obtained save when an aggressive paranoid mood was present.

From approximately one hundred investigations of the index in patients suffering from depressive reactions we ourselves have felt that it constitutes a guide provided care is taken to observe carefully the actual mood of the subject at the time of making the test. The index varies from a normal of zero to ten (to allow of experimental error in technique) to 100 as indicating maximum disturbance.

In a case of depression in which the blood sugar tolerance was followed throughout the reaction (Raphael, Ferguson and Searle, 1928), definite changes were noted in the curve coincidental with changes in the clinical condition of the patient. These changes were a high blood sugar peak following ingestion of the glucose and a slower return to normal. As the clinical condition grew more severe these became more marked, and a tendency for the fasting level to be raised was noted. As the reaction subsided there was a gradual return to normal on the part of the curve. It was noted, however, that in the latter part of the depressive reaction there was a tendency for the fasting blood sugar level to be a trifle low.

Craig (1927) examined a group composed of 50 cases of anxiety neurosis, 15 of epilepsy, and 25 of various forms of melancholia. He failed to find a characteristic curve for any of the disorders noted, but states that there was a failure to return to fasting level in two hours in 87 per cent of the cases of anxiety neurosis. He considered that this failure was to be accounted for by a mobilization of blood sugar to counteract some tonic process or by a partial suppression of the pancreatic hormone induced by a similar process.

His findings as to the fasting levels in his cases of depression have already been referred to. He found in addition that in certain of his cases there was a definite delay in the return to the fasting level and also that the maximum level after ingestion was in many cases abnormally high. Lorentz found that his depressive cases responded with curves higher than normal.

While, in the mood disorders and especially in their depressive phase, it is possible tentatively to suggest that one finds disorders of the sugar metabolism in the form of heightened curve, delay in return to normal, with possibly a raised fasting level in the later stages, these findings tend to become accentuated as the intensity of the mood disturbance is increased and subside as it grows less.

On leaving the mood disorders it must be said that to describe the changes as being due to the affective disorder is really an insufficient explanation. At the most, one may consider that it serves to define the problem a little more distinctly.

It is to be emphasized that what the patient feels is only one part and possibly quite a small part of the total reaction. Moreover, it is clear that in some cases, as in those where sexually symbolic stimulus words are used in the psychogalvanic test, the mechanisms of emotion may be largely set in action without their being perceived by consciousness. The situation in regard to other mental disorders is not so clear.

Schizophrenia. There are two aspects of glucose tolerance investigation in the schizophrenic reaction which require particular consideration. The first is the considerable variability in the type of curve which is found and the second is the fact that, according to recent workers, the curve in the case of catatonic stupor is more definitely abnormal than is the case in the other subtypes.

The first point is of special interest in view of the fact that the autonomic nervous system exercises considerable control over sugar metabolism, and much evidence is now available to indicate that that system functions inadequately in persons suffering from a schizophrenic reaction. (*See* the section on the autonomic nervous sytem.) Moreover, apart from sluggishness of action, the feature which most accurately distinguishes the autonomic nervous system in schizophrenia, particularly during the later stages, is variability of reaction. Hence it is to be noted that Kasanin (1926), who examined the glucose tolerance in 33 of his own cases and collected 154 additional records from the literature, states that, while no distinctive curve was forthcoming and the average fell within normal limits, there was a considerably higher percentage of abnormal curves than is found among control groups. Smith and Hill (1927), examining ten cases of schizophrenia, found the sugar tolerance was low. On treating the cases with thyroid and whole gland pituitary the curves tended to approximate normal and there was a gain in weight with an improvement in the mental condition of the patient. (*See* section on endocrines, Hoskins and Sleeper, 1930.) McCowan and Quastel (1931) found in 29 patients suffering from schizophrenic disorders that the blood sugar had not returned to the fasting level at the end of two hours after administration of the test glucose. They felt that this was possibly due not so much to a mood disturbance as to the abnormalities of endocrine function which they consider present in this reaction.

With regard to the second point, namely, that the reaction to the glucose tolerance test has special characteristics in the catatonic stupor, the following evidence is available. Lorentz (1922) in his series of 52 cases found that while the average maximum rise of the paranoid group was within normal limits and that of the simple and hebephrenic groups was rather low, being 0.13 per cent and 0.14 per cent respectively, the average maximum rise for the catatonic cases was over 0.20 per cent. He states that in none was there a complete return to normal at the end of two hours, this being particularly marked in the case of the catatonic group where the two hour reading was 0.16 per cent as contrasted with a fasting level of 0.12 per cent. Kasanin (1926) found that the glucose tolerance curve was unduly prolonged in a considerable percentage of his cases. McCowan and Quastel (1931) were not able to find this sustained hyperglycemia in those cases of catatonic stupor in whom they carried out the glucose tolerance test.

Apart from these two aspects of sugar metabolism in schizophrenia, which have just been considered, the rather extensive work in this field has yielded limited results. It is possible that this may be rectified as the technique is improved. More attention is being directed to the necessity of assessing the precise reaction, particularly the tensional state, of the patient at the time the investigation is being carried out. Moreover, it is now becoming clearer that the schizophrenic reaction is characterized not only by a progression in symptoms but also by progressive deterioration in biochemical and physiological reactions. It is quite necessary that any statement concerning the sugar metabolism of the schizophrenic patient should be accompanied by as precise a record as possible of the degree of psychobiological deterioration present in the individual under study.

Epilepsy. It has already been pointed out that no deviation of the fasting blood sugar has been found to exist in idiopathic epilepsy. In the case of the sugar tolerance test a similar situation obtains. There are few indications that any abnormality of sugar metabolism can be demonstrated as causative of the convulsions or as being associated with any other aspect of the epileptic reaction.

Craig (1927) examined the sugar tolerance curves in 15 patients suffering from epilepsy. He found nothing abnormal save that in a number of cases the blood sugar level did not return to normal at the end of two hours. Minchin (1933) reports, however, that he found some degree of hypoglycemia in a series of 80 epileptic patients whom he studied. The average fasting level for the group was 84.9 mg. per cent; 26 per cent of the patients had blood sugar levels below 80 mg. per cent. In 66 of his patients the sugar tolerance curves were investigated. An abnormally large number of low curves was found. Minchin suggests that this low sugar level may be due to overactivity of the islands of Langerhans. He also puts forward the view that the convulsions may be regarded as a protective device since the blood sugar level rises after a fit. Status, he considers, may be regarded as fits occurring when there is no reserve of glycogen in the liver.

The seizures which occur in conditions when the blood sugar falls to very low levels, as in the insulin hypoglycemia treatment of schizophrenia, are probably best considered as analogous to those arising in states of cerebral anoxia. In both situations there is a profound reduction in the metabolic rate of cerebral tissue.

Mann (1925) in order to test the glycogenic efficiency of the liver in cases of mental disorders, made use of the levulose test. It has been previously shown that in cases of hepatic disease levulose appeared in the urine. In 18 normal controls the test was negative; in 55 cases of early mental disorder 2 doubtfully positive reactions occurred and in 19 patients suffering from more severe and advanced psychotic reactions 9 doubtful responses were obtained. He is inclined to feel that the cause of the sustained hyperglycemia may be depression of pancreatic function, possibly dependent on a change in the ionic condition of the patient.

Mann and Scott (1929) sum up their work with the blood sugar levels in psychotics by saying that it is fairly generally agreed that the fasting blood sugar is within normal limits, but that the sugar tolerance curves are high and variable, that there is a tendency toward sustained hyperglycemia. They believe that these abnormalities cannot readily be correlated with the various abnormal behavioral reactions as they appear in our present classifications. These workers showed by the addition of insulin to the glucose meal that the abnormality of the curves is not due to actual pancreatic deficiency but rather to another agent which they believe to be a disturbance of the acid-base balance which results in a shift of that balance to the acid side. They also suggest that this deviation in the acid-base balance may account for the paradoxical results which are sometimes obtained in psychotic patients in response to the administration of sympathetico-mimetic and parasympathetico-mimetic drugs and endocrine preparations. They point out that acidity inhibits glycogenesis by insulin while it increases oxidation of carbohydrates. Alkalinity facilitates the action of insulin in promoting glycogenesis.

Psychoneuroses. Glucose tolerance has been reported as reduced in this group. It would appear from the data recorded that this lowering of the glucose tolerance is particularly likely to occur when states of tension are present and that the degree of disturbance of the curve keeps pace with the degree of tension. Quite marked disturbances are found in panic states. These disturbances take the form of an unduly large rise in response to the injection of sugar and an unduly slow return of the blood sugar curve to normal. This has been well shown in repeated studies of the glucose tolerance in the same individual while under varying degrees of tension (Diethelm, 1936).

Blood Sugar Changes Causative of Behavioral Reactions. As indicated at the beginning of this section variation in carbohydrate metabolism may be associated with variation in behavior either as a concurrent or as a causative factor. Those reactions, in which variation of carbohydrate metabolism accompanied but did not seem to cause the current behavior, have already been examined. We now propose to consider the effects which variation in carbohydrate may produce in behavior.

The level of the blood sugar is our most available index *in vivo* of carbohydrate metabolism. It may at the outset be stated that considerable fluctuations in the blood sugar level may occur without any effect upon behavior becoming discernible; it may also be stated that the blood sugar level at which variation in behavior will become apparent differs considerably from individual to individual.

The most valuable source of information concerning the effects of marked decrease in carbohydrate metabolism consists in the work which has been done upon the insulin treatment of schizophrenia (Sakel, 1935). In patients under this form of treatment the blood sugar is reduced to low levels by the massive doses of insulin which are used and further release of glucose from the liver is inhibited. It is to be borne in mind that a final opinion as to whether insulin may exert, in addition, a direct effect upon the central nervous system has not yet been reached. The psychobiological reactions shown by the patient in whom carbohydrate metabolism has been reduced by a failure in the production of insulin, *i.e.*, the diabetic, have not been well worked out.

The observations upon the effects of reducing carbohydrate metabolism by means of massive doses of insulin have been recorded for the most part in schizophrenic individuals. The reactions vary greatly from individual to individual. In general it may be said that, as the blood sugar goes down, a preliminary period of drowsiness sets in. An exception to this is furnished by patients suffering from catatonic stupor. In these patients there is quite frequently a temporary arousal from their stupor. Following upon the period of drowsiness a phase of increased activity sets in; this usually passes over into a stage of jerking, grimacing and twitching. This in turn subsides as the patient passes into coma.

During the developing hypoglycemia a great range of behavioral patterns may occur. Wall (1940) has described sexual activity extending from simple rubbing and sucking movements, through masturbatory activity up to well organized coitus movements. He suggests that there tends to be a progression to the more fully differentiated types of sex activity as the patient's clinical condition improves. Frostig (1940) has investigated the neurologic effects of progressive interference with carbohydrate metabolism as produced by large doses of insulin. He considers that the neurologic symptoms appear in an order inverse to the phylogenetic age of the various levels of the central nervous system.

The effects of increased carbohydrate metabolism upon behavior have been barely touched upon. Cameron (1938) has reported that the more rapidly glucose is administered to patients in hypoglycemic coma the more marked is the euphoria which they demonstrate on arousal. It is probable that in such cases there is a greatly increased carbohydrate metabolism, but whether the euphoria arises from this or is to be associated with the speed of termination of the coma is unknown. A similar euphoria is not seen in injection of large amounts of glucose and insulin in patients who are not in hypoglycemia.

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CHAPTER XVI

BASIC METABOLIC ACTIVITIES (*Continued*)

Protein. The relationship of protein metabolism to behavior has not been so extensively studied as has that of carbohydrate. Hoskins (1937) refers to preliminary work suggesting that the heat production which follows upon the ingestion of protein is less in the schizophrenic group than in the normal. The actual blood levels of albumin and globulin in schizophrenic patients have been investigated by Schrijver and Schrijver-Hertzberger (1932). These authors have reported that while the total blood protein values in schizophrenia are within normal, high fibrin values and low albumin-globulin values are found to be associated with cases having a good prognosis. Gildea *et al.* (1940) have reported that long term studies of both manic depressive and schizophrenic patients show that considerable fluctuations of the total protein content of the blood tend to occur in those patients who show definite variations in the clinical picture. In those patients in whom there was little change the total protein level was not remarkable.

Considerable interest has been directed to the report by Fölling (1934) to the effect that certain types of mental deficiency are accompanied by the excretion of phenylpyruvic acid in the urine. An extensive investigation of this phenomenon by Jervis (1937) suggests that it may be of genetic origin. The source of the phenylpyruvic acid appears to be an error in the breakdown of phenylalanine. The condition is accompanied by neurologic symptoms as well as the intellectual defect. An approach to the determination of the amino acid content of the blood in a group of abnormal behavioral reactions is reported by Looney (1924). Lacking a direct method of attack he worked out the undetermined nitrogen since the amino acids constitute part of this. No significant variations from normal were found in groups of psychoneurotics, mood disorders and schizophrenics.

Gjessing (1932, 1938) has found fluctuations in nitrogen retention and output which he has been able to associate with variations in the catatonic reaction. He considers that this arises from a disturbance of protein metabolism. This is considered in the section of the catatonic reaction. In brief, by means of daily estimations of nitrogen intake and output over a period of years Gjessing has been able to show two types of correlation between the behavior of the catatonic and his nitrogen metabolism. In the first type there is a gradual retention of nitrogen which continues until a threshold is reached which is characteristic for the patient. When this is attained the reactive phase — either stupor or excitement — sets in and elimination starts. This may persist throughout the reactive phase and part of the quiescent phase or it may terminate while the patient is still excited or stuporous, and nitrogen retention may again set in. In the second type the reactive phase sets in when elimination has reached its lowest level. In these cases retention is carried on during the reactive phase. In those cases in which nitrogen retention appeared to be associated with the onset of the reactive phase it was possible to prevent the appearance of this phase by lowering the nitrogen level by means of thyroxine and desiccated thyroid.

Since creatinine arises solely from endogenous protein metabolism interest attaches to its rate of appearance in the urine (Penrose and Pugh, 1939). These workers in their approach to the problem were guided by the fact that endocrine disorders tend to produce abnormalities in the excretion of creatinine and creatin. The latter is said not to appear in the urine of normal men and only occasionally in the urine of women. Penrose and Pugh examined the urine of 300 male and 100 female mental defectives over the age of 16 with reference to the excretion of creatinine and creatin. They found that when mental deficiency was accompanied by myopathy the creatin excretion rate was very high while that of creatinine was correspondingly lowered. Diplegic cases showed similar results while those patients who suffered from hemiplegia tended to fall within normal limits. In cerebellar ataxia and in those patients who showed postencephalitic syndromes there was a significantly high excretion of creatinine. When endocrine disorders were concurrent, the excretion rates for both creatinine and creatin were abnormal. In uncomplicated cases of mental deficiency or when such cases showed, in addition, a psychotic reaction there was apparently no disturbance of excretion of either creatinine or creatin.

Fat Metabolism. In considering carbohydrate metabolism it was possible to group the known facts as those concerning the effects of variations in carbohydrate metabolism upon behavior and as those concerning variations which accompanied particular kinds of behavior. This is barely possible in the case of lipoid metabolism. The effects on behavior of increase or decrease of lipoid metabolism have not been adequately investigated. We have some familiarity with the phenomena of the ketogenic diet. Since, however, the results of this procedure are at least as much dependent upon the limitation of the carbohydrate intake as upon the increasing of the fat ration, it is questionable whether we are justified in including this in our considerations. The behavioral changes which accompany progressive ketosis are simply those of increasing clouding of consciousness. The individual finally passes through a stage of delirium into complete loss of consciousness. While experimental work on rats has shown that these animals cannot be reared successfully if certain of the unsaturated fatty acids —

linoleic, linolenic or arachidonic acid — are absent from the diet little is known concerning the precise function which these fatty acids fulfill. It is possible for the adult man to subsist for as long as six months on a diet which is low in fats without definite behavioral change. Lowering of the serum linoleic and arachidonic acids occurs however (McCollum, Orent-Keiles, Day, 1939). Nothing is known concerning the effects upon behavior of increase in the metabolism of fat.

Interest has been directed toward the relationship between blood fats and body build. Mjassnikow (1927) states that he found that the average blood cholesterin content in normal hyperasthenic individuals was 0.18 per cent while the average figure for normal asthenic persons was 0.13 per cent. Tschernorutzky (1929) gives readings of 0.17 per cent for the hyperasthenic group and 0.13 per cent for the asthenic group. By hyperasthenic he understands the pyknic type of Kretschmer and the macrosplanic type of Viola and Pende. By the asthenic type he understands the leptosome as described by Kretschmer and the microsplanic of Viola and Pende. It is not, however, altogether clear whether the degree of nourishment may not have played a considerable part in the difference in cholesterin levels. Petersen has contrasted the cholesterol levels of a group of slender and heavy individuals. In the former he found the average cholesterol value was 210 mg. and in the latter 225 mg. Gildea, Kahn and Man (1936) have reported that the total fatty acids and blood cholesterol were significantly higher in individuals of the pyknic type than in those of the leptosome type. They found, too, that the energy output in the former group was greater than that of the latter. It was difficult to correlate specific personality characteristics within these two groups.

The earlier work upon the blood fat levels in various types of abnormal behavior suffered considerably from a failure to realize that even the fasting level fluctuates considerably within a given individual and that the level is particularly affected by certain variables, such as the degree of activity of the individual. Present studies are based almost exclusively upon multiple investigations on single individuals with attempts to work out correlations between the blood fat levels and behavior. As a variation in this procedure, may be mentioned studies on various stages of a particular type of behavioral disorder. The former procedure has been used by Gildea, Man and Barach (1940) who followed a group of schizophrenic and manic depressive patients through extensive variations in behavior. They found that both blood cholesterol and fatty acids tend to be elevated during the manic depressive reaction and fall as remission takes place. The values in the case of the schizophrenic patients were found to be below normal. Moreover, it was noted that, when the schizophrenic reaction was complicated by the presence of affective features, considerable fluctuations tended to occur in the blood fat levels.

Stenberg (1929) has made use of both procedures — repeated examination of individual patients passing through a psychotic reaction and examination of groups of individuals at various stages of a psychotic reaction. He has found that the manic-depressive patient tends to show an elevation of blood cholesterin and fatty acid during his illness and that this elevation tends to return to normal as the patient recovers. In this he is in agreement with Gildea and his co-workers. Stenberg reports further that these levels are also elevated in the early stages of the schizophrenic reaction and tend to fall to normal or subnormal levels in schizophrenic cases of long duration. He considers that these variations in both the manic-depressive and schizophrenic groups may possibly be reduced to a common basis. On further analysis of his extensive data he finds that when there is considerable emotional disturbance there is, regardless of the nature of the psychosis, an elevation of the blood cholesterin and fatty acid levels.

When there is no emotional disturbance or when apathy is present these levels are either within the limits of normal or are subnormal. Duncan (1930) was not able to confirm this relationship between the blood cholesterol level and the emotional status of the individual. Looney and Childs (1933) followed a group of chronic schizophrenic patients over a period of seven months. They found that the mean level was somewhat below normal but that no correlation with the emotional reaction of the patient could be substantiated. Brice (1935) found that the blood cholesterol and fatty acid levels were lowered in the schizophrenic group and that this lowering was particularly marked in the apathetic, stuporous type of patient.

A further approach to the problem has been made by Randall, Cameron and Looney (1938) who studied the effects of insulin treatment upon the phospholipid, total lipid and total cholesterol levels of the blood in a group of schizophrenic patients undergoing insulin treatment. They found that a rise in these levels occurred in all patients shortly after the initiation of treatment. In those patients in whom a remission occurred this rise was maintained. It was not maintained in the patients in whom a remission did not take place.

This approach was developed further by Randall and Jellinek (1939). They investigated the response of 22 patients suffering from early schizophrenia to insulin treatment with respect to the serum lipid levels (phospholipids, total cholesterol, free cholesterol, cholesterol ester and total lipids). They found that prior to treatment all lipid values with the exception of free cholesterol were below normal.

Following treatment all levels with the exception of free cholesterol were significantly increased. This increase occurred in those patients who proceeded to remission and those who did not. The intra-individual variation of the values was, however, reduced in those patients who subsequently recovered while it tended to increase in those who did not recover. Moreover, the two groups were further differentiated by the fact, noted in the earlier investigation, that the elevation in values was maintained in the recovered group but fell back to the initial level in those patients in whom a remission did not occur. These changes in lipid levels were independent of changes in weight and of the magnitude of the insulin dosage.

Acid-Base Balance. The maintenance of a constant acid-base balance is of the greatest importance to the organism. The *p*H of the blood is normally steady, fluctuating between 7.35 and 7.45. This level is preserved by means of a complex system of buffering. Excess of alkali and acid is dealt with by the renal and respiratory mechanisms.

Should the acid-base level be seriously disturbed and a condition of acidosis or alkalosis set in, behavior becomes progressively abnormal. Reference has already been made to the development of delirium and later coma which attends a deepening ketosis. Our information in this field is, however, largely observational. No experimental work of note has been done upon the effects which alkalosis or acidosis produces on human behavior. The extent to which alkalosis or acidosis may accompany, as distinct from cause, changes in human behavior has received more attention.

Some preliminary work has been carried out upon the acid-base balance in various personality types, in emotional reactions and in stutterers as well as in certain of the major abnormal reaction types. Hamilton and Stock (1936) have investigated the relationship of *p*H of the blood serum and the CO_2 content of the blood to certain personality characteristics, chiefly introversion and extroversion. The study was carried out upon 137 college students. No clear-cut correlations could be demonstrated. The small correlations which were present were considered by the authors to arise from the inadequate respiratory patterns which occurred with unusual frequency in the more unstable members of the group. Rich (1928, 1933) has studied the relationship between body acidity and emotional responses. As indices of body acidity he placed most reliance upon the reaction of the saliva and the urine. He reports that individuals who are prone to be excitable show greater acidity both of urine and saliva than do more placid persons. This seems possible of explanation on the basis that excitable persons tend to be more active. Activity in them produces increased production of lactic acid with the result that a greater excretion of acid is necessary. Starr (1922) examined the saliva in a large group of stammerers. He found that 73.7 per cent of the group were what he termed "sub breathers." The salivary *p*H was abnormally low; this the author attributed to an inadequate elimination of CO_2 by the respiratory apparatus.

Investigation of the acid-base balance in the major forms of abnormal behavioral reaction has shown that there is no deviation from normal in the case of the manic depressive psychosis (Appel, Farr and Hodes, 1931). Similarly there is little evidence of disturbance of the acid-base balance in the psychoneurotic group.

More difficulty exists in determining whether there is any interference with the balance in the schizophrenic reaction. There is evidence that oxygen utilization may not be normal, at least in the more chronic schizophrenic patients, and also some evidence that the respiratory center responds sluggishly. Hoskins and Jellinek (1934) put forward the first proposition as a possible explanation of their findings to the effect that the mean venous lactic acid level in a group of schizophrenic patients was 144 per cent of normal. Golla, Mann and Marsh (1928) put forward the second proposition, namely, the sluggish response of the respiratory center to CO_2 as evidence of a failure in compensatory behavioral mechanism of the acid-base balance. Unfortunately the type of abnormal behavioral reaction with which they were working is inadequately defined. Nims *et al.* (1940) have investigated the mechanism of the elicitation of petit mal attacks in epileptics by means of overventilation. The workers were primarily interested in the question of whether the nerve cells of the epileptic brain were abnormally sensitive to alkalosis produced by overventilation or whether this respiratory alkalosis was different in epileptics from that which obtains under the same circumstances in normal individuals. They made repeated estimations of the *p*H of arterial and internal jugular blood of patients suffering from petit mal epilepsy and of normal controls taken before, during and after voluntary hyperventilation. From their findings it appears that hyperventilation produces a greater and more sustained drop in the carbon dioxide content of the internal jugular blood of the patient group than it does in the case of the normal controls.

Chlorides. The metabolism of chlorides seems to be of considerably greater importance for lower level functions than for behavioral level functions. While the blood chloride level assumes considerable importance in disorders of the kidney and in certain gastro-intestinal conditions, it is rarely found to be disturbed in patients suffering from abnormal behavioral reactions.

It has frequently been reported that excessive loss of NaCl through sweating may produce spasm — the so-called miner's cramp — and it has been suggested that excessive loss of NaCl may account in part for the lassitude and lack of energy shown by persons working in hot climates. The part which the chlorides play in these conditions and in the behavioral changes accompanying Addison's disease is further complicated by the fact that it is a loss of NaCl that takes place, not a simple loss of Cl.

The blood chloride level in the schizophrenic group has been investigated by numerous authors and found to be within normal limits (Bowman, 1923). It has also been reported as normal in the manic depressive reaction (Henry and Mangan, 1925; Appel, Farr and Hodes, 1931) and in the psychoneurotic syndromes by the three groups of investigators just cited. Armstrong (1929) has, however, suggested that, in the schizophrenic group, the distribution of chloride within the blood may not be constantly normal. In the normal organism the red blood cells have a buffering action in that they take up the acid chlorine ion, setting free sodium to combine with excess of carbon dioxide in the plasma. During sleep the respiratory mechanism which is an important agent in the removal of surplus CO_2 is depressed and consequently the amount of chlorine ion found in the red blood cells is increased. In the schizophrenic patient, however, the red blood cells, according to Armstrong, carry a heavier chlorine load during the day than night. It is suggested (Golla, 1929) that in this group the responsiveness of the respiratory mechanism is reduced and that consequently it is necessary during the daytime to call heavily upon the buffering action of the red blood cells to deal with the acid produced by muscular activity. During the night the production of acid falls off and consequently the red cells do not have to carry so much of the burden.

Phosphorus, Calcium, Potassium. The metabolism of these minerals has been explored to some extent with reference to its relationship to behavior. There are indications that there may be important connections. It is already known that the inadequacy of blood calcium is associated with muscular spasm. Both calcium and potassium have an influence upon the excitability of nervous tissue, while phosphorus is not only intimately involved in the fat metabolism of nervous tissue but also plays an important part in the activity of the adrenals (Verzar and Laszt, 1936). Finally there are the problems connected with the abnormal deposition of calcium in aged persons, where the blood calcium remains at the same time within normal limits.

In spite of these significant correlations between lower level activity and mineral metabolism the effect of the latter upon human behavior is practically unknown. No significant work has been done upon the results in terms of human behavior of drastic interference with the metabolism of phosphorus, calcium or potassium. Moreover, no general agreement has been reached by those who have investigated the blood levels of these minerals in the various abnormal behavioral reactions. Hypercalcemia has been reported in schizophrenia as frequently as hypocalcemia, and the same is true of the manic depressive group. There appears, furthermore, to be no definite correlation between the blood levels of these two minerals and the degree of activity. The blood calcium level in aged persons is reported as being within normal limits (McCay, 1939) and the explanation of the abnormal deposition of calcium in these persons is still to be sought.

It is of interest to note that Looney, Jellinek and Dyer (1939), in a careful study of the potassium, calcium and phosphorus levels in the blood of a group of schizophrenic patients before and after insulin treatment, found no changes in the potassium and calcium levels which could be ascribed either to treatment or to recovery. In the case of inorganic phosphorus it was found, however, that the pretreatment level of this mineral was significantly raised above that of the normal control group and that in those patients who showed a remission following on treatment the inorganic phosphorus level dropped to normal limits. This finding is in accord with those reported by the Worcester group which suggest that following upon insulin treatment there is an increased activity of the adrenal-sympathetic mechanism and that this increased activity is more marked and better sustained in those patients who develop a remission than in those who are not favorably influenced by the treatment.

Water. The metabolism of water is clearly a matter of fundamental importance to the individual if only because water constitutes by far the greater part of the organism. Technical difficulties still prevent any wide exploration of the field. It is, for example, hard to establish criteria of dehydration. We have on several occasions seen patients admitted to hospital with a history of a failure to take adequate fluids and all the evidence of clinical dehydration together with a high blood viscosity. Correction of the viscosity by the intravenous route has in certain of these patients failed to overcome the clinical evidence of dehydration. The tongue and lips remained dry and excoriated; there was severe constipation and suppression of sweating and of urination. The hypothesis may be advanced that in these cases the fluid which was added has remained outside the body though within the circulatory system. The mechanisms whereby fluids are distributed from the circulatory system to the tissues appear to be damaged.

Preliminary work has been done, mainly in animals, upon the effects of administering excessive amounts of fluid and upon the effects of withholding fluids. Rowntree (1923, 1926) has shown that forcing large amounts of fluid in animals will produce weakness, muscular irritability, convulsions, coma and finally death. In the human subject it has been noted that, if pitressin is given to patients suffering from diabetes insipidus in amounts large enough to interfere seriously with their urinary excretion, similar symptoms will appear. Headache and weakness, incoordination and staggering gait appear. Evidence of increased intracranial pressure is present, and in the case of animals dying from water intoxication there is edema and the cerebral vessels are distended (Helwig, Schutz and Curry, 1935). The behavioral changes produced in the human subject by dehydration vary considerably between individuals. In general there is growing weakness, confusion, delirium and finally coma. The picture is usually complicated in its later stages by the development of an acidosis.

Considerable interest has been directed toward water metabolism in epilepsy. It was suggested by Fay (1929) that cerebral hydration may be a factor in the production of the convulsive reaction. The work which has been done on this has been considered extensively in the section upon the convulsive reaction.

Comparatively little work has been done upon the occurrence of dehydration in toxic states and in excitement reactions. It seems possible that many of those cases of "fatal catatonia" which have been reported, particularly in the German literature, are actually cases of excited catatonia in whom dehydration and acidosis developed but were not recognized. The post-mortem findings which have been published on these cases show very little which could not be accounted for on this basis.

Water metabolism changes progressively with age. In the older organism there is a very considerable loss of fluid from the tissues (Bürger, 1934), particularly from the tissues of the central nervous system (McCay, 1939). The influence which this exerts upon the behavioral changes associated with aging is still quite unknown.

Frequent reference has been made during consideration of these basic metabolic functions to the divergence of reports made by various workers. With such relatively precise methods of estimation it seems at first sight extraordinary that so little agreement was obtained. When one considers, however, how frequently the biochemist has been content to consider that one patient labeled schizophrenic is identical with another so classified it is less difficult to understand the lack of agreement. Very frequently little attention has been paid to age, duration of illness, subtype of illness or to the patient's general reaction at the time the isolated blood sample was taken for investigation. This matter is well discussed by McFarland and Goldstein (1937). A good example of the importance of long term studies and a critical statistical review of the data are afforded by the demonstration that schizophrenic patients show a seasonal variation with respect to their blood cholesterol (Jellinek and Looney, 1936).

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CHAPTER XVII

EFFECTS OF DRUGS UPON BEHAVIOR

A CONSIDERABLE range of chemical preparations have been employed for the purpose of investigating behavior. It is possible to place these preparations in the following groups: (*a*) those used in order to reproduce or intensify certain aspects of behavior, *e.g.*, mescalin with reference to its action upon projections and bulbocapnine with respect to effects upon mobility; (*b*) those drugs which have special effects upon behavior, the most common being a release from higher level control. Such drugs are sodium amytal and alcohol. Finally a group (*c*) can be delimited which is comprised of drugs which throw indirect light upon behavior by virtue of the information which they afford concerning lower level functioning. Such drugs are the bromides, as used in the bromide permeability tests, and those drugs which affect the brain wave pattern of epileptic patients.

Caffeine. Some of the earliest work upon the effects of drugs on behavior has centered around caffeine. Of chief interest has been the capacity of the drug to increase the speed and to some extent to improve the quality of higher level activities. The earlier workers (Dietl and Vintschgau, 1878) showed that moderate doses of caffeine usually taken in the form of tea or coffee resulted in a shortening of the simple reaction time. Kraepelin (1892) showed that moderate doses of the drug increased the speed of addition and reading, as well as producing a feeling of greater briskness and clearness. Ach (1901) pointed to an increase in the power of perception and an increase in the speed of performance together with an increase in the number of mistakes in carrying out test procedures. Hollingworth (1912) demonstrated numerous technical errors made by some of the earlier workers but confirmed the increased speed of psychomotor performance, using for this purpose the tapping rate. He demonstrated that small doses of caffeine (1–3 gr.) increased coordination while large doses (6 gr.) decreased coordination. He reported that the caffeine stimulates such higher level functions as are involved in the opposites test, tests of calculation and cancellation tests. McDougall and Smith (1920) report that after ingestion of caffeine there is an increase in the rate at which an ambiguous figure will fluctuate. This is in harmony with the fact that there is an increase in this rate which parallels the increased activity of the person recovering from a depression. Allers and Freud (1925) state that they have found that the administration of caffeine in the form of coffee will increase imagery, though they found little increase in the ability to reproduce material.

The work of later investigators has not advanced our knowledge of the way in which caffeine produces this increase in the speed of psychomotor responses, though this clearly might be of importance in understanding states of decreased responsiveness such as one finds in the catatonic and depressive reactions. Cattell (1930) reports that small doses of caffeine (0.2 gm.) result in deterioration of performance on intelligence tests and a simultaneous improvement in memory. This improvement in memory is true both for recent and remote events. He makes a further contribution in urging that experimentation in this field should include careful control of age, constitution and sex in the group under investigation. Wolff (1935) has made use of the conditioned reflex technique to demonstrate that caffeine results in an increase in the conditioned response. Mullin, Kleitman and Cooperman (1933) have shown that larger doses of caffeine (4–6 gr.) result in an increase of mobility during sleep. The fact that such doses tend also to interfere with the onset of sleep has been widely established. Thornton, Holck and Smith (1939) have repeated some of the earlier work concerning the effects of caffeine on psychomotor activity. They have used the reaction time, tapping and steadiness tests and find that the drug improves the performance on all tests with the exception of those involving steadiness. Here a deterioration appears.

Extensive work upon the effects of caffeine on lower level activities has been carried out. This may be summarized by saying that caffeine appears to produce a generalized dilatation of vessels, and, in small or moderate doses, a slight rise in blood pressure. In the same doses there tends to be an acceleration of the heart rate. Finesinger (1932) has demonstrated that there is a dilatation of pial vessels in the cat in response to small doses of the drug; and Gibbs, Gibbs and Lennox (1935) found that the cerebral blood flow in man is slightly diminished. This latter finding is at variance with similar work on animals; moreover, it is on first consideration difficult to reconcile a diminished blood flow with the increased responsiveness of the higher level functions.

Bulbocapnine. This drug has been used primarily for its effects in reducing the activity of the organism. Experimental work has been almost entirely limited to animals. The behavior which follows upon its administration closely resembles that which is seen in the human catatonic reaction. The work done in this field is considered in some detail in the section on the catatonic response.

Mescalin. The use of mescalin in experimental work upon hallucinations has already been described in the section upon thinking. In addition to the effects already considered the drug may produce considerable distortions of the body image so that the subject may feel that various parts of his body have grown out of all proportion (Klüver, 1928). This effect has resulted in attempts to study the phenomenon of depersonalization as it occurs in psychotic individuals (Guttmann and Maclay, 1936). The influence of the drug under such conditions is various; in some instances there is an increase in the feeling of depersonalization; in others it is alleviated. Little further insight into the mechanism of the condition has been obtained.

In view of the disturbance in perception, the depersonalization and the disturbances of thinking which occur in the more severe grades of mescalin intoxication, suggestions have been made that mescalin presents a method of studying an experimentally produced psychotic reaction (Guttmann, 1936; Stockings, 1940). From the work which has so far been completed in this field it does not appear, however, that the picture presented is more than that presented by any intoxication with the addition, of course, of the special features which have been described. There seems to be little justification for considering that there is any close similarity between the mescalin intoxication and schizophrenia.

The disturbances of time sense which may occur during mescalin intoxication are rather reminiscent of those seen in patients under the influence of hashish. They await more adequate investigation.

Benzedrine. This agent, which was originally introduced as a substitute for ephedrine in the treatment of excessive nasal secretion (Miller and Piness, 1928), has been found to exert a considerable influence upon behavior. The main interest in the drug as a research tool has consisted in the light which it might throw upon the mechanism of mood. Peoples and Guttmann (1936) drew attention to this fact in their report upon its effects upon a group of psychotic patients. They stated that in this group the drug evoked mood changes in the direction of elation. Myerson (1936) reported that in normal persons who were fatigued or tended to be slightly depressed in the morning the preparation acted to produce a feeling of energy and cheerfulness.

Much of the work is still upon an observational basis, largely due to the difficulties involved in working out procedures for objective registration of the effects produced. Sargent and Blackburn (1936) have reported that the score of a group of institutionalized patients on the Cattell intelligence form was raised 8 per cent following the administration of benzedrine. Thornton, Holck and Smith (1939) have reported that the administration of benzedrine increased performance in a series of psychomotor tests which included tapping time, reaction time and tests of steadiness. Investigation of the lower level action of the drug shows that it exerts its principal action upon those functions which are integrated by the sympathetic nervous system. Its action is, however, not equally marked on all aspects of this system. There is consistently a pressor effect, the blood pressure being raised to a moderate degree over a period of several hours and there is probably also an effect upon the musculature of the gastro-intestinal tract. This consists in a tendency to relax spasm of the pylorus and colon (Myerson and Ritro, 1936). However, there is little effect upon the blood sugar level. There is no correlation between the pressor effects and the influence upon behavior, and Bloomberg (1939) states that he considers that there is evidence that benzedrine has a central as well as a peripheral action. In this connection it is of interest to observe that while Cutts and Jasper (1939) noted an improvement in the behavior of almost half of a group of problem children under benzedrine no correlation between the changes in behavior and change in the electroencephalogram was observed.

The purely observational material concerning the action of this drug upon behavior is now quite extensive. Reifenstein and Davidoff (1939), from an extensive experience with the preparation, report that they consider that the psychological effects can be stated as consisting in (1) a stimulation of the mental activity, this consisting in greater alertness and initiative, increase in perception and improvement on psychomotor scores; (2) increased activity of the speech function, this resulting in loquaciousness, greater accessibility in the case of inhibited patients and diminution of mutism; (3) increase in motor activity, which may be accompanied by tremor and restlessness and (4) mood changes in the direction of cheerfulness, confidence and assertion. Together with these changes they report that paradoxical reactions may occur. The subject may, for example, become dull, inactive and inaccessible. In consequence of these various actions the preparation has been used in a wide range of situations: in alcoholism, in depression, narcolepsy, neurasthenia and schizophrenia. The results are best in narcolepsy and in mild depressive reactions.

In spite of the very considerable amount of work which has been carried out upon this drug relatively little further knowledge has been gained concerning the nature of affective reactions. The preparation has been termed a sympatheticomimetic or an adrenergic drug, but this clearly takes us little further in the direction of understanding the psychobiology of mood reactions. Bloomberg (1939) has suggested that benzedrine may resemble very closely or indeed be identical with one of the sympathins which are normally elaborated in the organism.

Several drugs have been utilized because of their action in promoting release from inhibition. This phenomenon is of value not only in the study of the reactions of otherwise inaccessible patients but also in the investigation of lower levels of mentation. This is rendered possible by the fact that the disinhibiting drugs tend to interfere with the higher level functions first. Reference has already been made in this section to the action of cocaine in producing greater accessibility in the catatonic reaction. Sodium amytal exerts a somewhat similar action in this regard, which has been considered in the section upon the catatonic reaction. Progressive interference with cerebral metabolism, as when the oxygen supply is gradually cut down or when the supply of glucose is reduced as in insulin hypoglycemia, also results in progressive release from higher level control. The effects of oxidation deprivation are discussed in the section on the oxidative function, and the effects of glucose deprivation are taken up in the section on carbohydrate metabolism.

Alcohol. Alcohol has been extensively used as an investigative tool by reason of its capacity to effect the release of lower levels of mentation from higher level control. Obermeier (1873) reported that ethyl alcohol given by mouth rendered inaccessible depressed patients considerably more approachable. Kantorovich and Constantinovich (1935) administered the same drug both by mouth and in a 20 per cent intravenous solution to catatonic patients. They found that a temporary release from mutism and negativism occurred. In some instances the mutism was permanently overcome. Trapp and Schube (1937) used the drug by mouth and obtained similar results. They emphasized the value of this procedure as a means of obtaining better understanding of the underlying factors in the illness. The effects of alcohol are known to vary considerably from individual to individual and within the same individual, depending on his state of fatigue, his mood, as well as other factors. Newman (1935) reports that the effects also vary from one type of abnormal behavioral reaction to the other. Intravenous injection of 10 per cent solutions in normals tended to produce an increased verbal output, and an intensification of the preexisting mood. In the psychoneurotic group, however, Newman found that in addition to increased talkativeness, there were emotional outbursts together with an intensification of the patient's symptoms. While accessibility increased in the psychoneurotic group it was found that the schizophrenic patient tended to become less approachable. He frequently became antagonistic and negativistic. This is contrary to the findings of other workers.

A considerable amount of work has been done upon the effects of alcohol in the human subject. The earlier workers were in general agreement (Karlson, 1913) that the higher level functions are first and most severely affected. It must at the same time be admitted that even at the present time we have great difficulty in defining what we mean by higher level functions and still greater difficulty in measuring them with any degree of precision. Wherever a relatively exact means of measurement is available, however, it is possible to demonstrate the action of alcohol upon mentation. Jörger (1915) made use of the then recently devised word association technique to demonstrate that alcohol produces not only a lengthening of the reaction time, but also a tendency to repeat the the stimulus used. He also found a greater number of personal associations, an increase in the amount of perseveration, and an impoverishment of the capacity to reproduce the original reaction word. The interference with the function of learning in lower animals has been demonstrated by Arlitt (1916). He showed that rats exposed to alcohol were considerably slower in learning to run a maze and made more errors than did control rats. The general slowing and inaccuracy of the higher level functions in the human subject have been studied by McDougall and Smith (1920) who made use of the reaction time, the fluctuation of an ambiguous figure and a dotting test to demonstrate this fact.

The relationship of alcohol to memory disturbance and the mechanism whereby the severe retention failure associated with the alcoholic Korsakow reaction is brought about has not yet been subjected to experimental investigation. There is, however, already some evidence to suggest that this may eventuate as an indirect result of interference with the ingestion of various parts of the Vitamin B complex rather than as a direct action of alcohol upon the nervous system.

Certain of the behavioral changes produced by alcohol have a striking resemblance to those brought about by exposure to low oxygen tensions. The effects of alcohol in setting aside the catatonic stupor reaction are similar to those of insulin. It is probable that the basis for these effects is the same in all instances, namely, that there is a progressive interference with cerebral metabolism. Page (1937) refers to experiments which indicate that alcohol in larger amounts acts to diminish the oxygen consumption of brain tissue.

The use of sodium amytal as a means of setting aside the catatonic stupor reaction has already been considered in the section on that reaction while the effects of increasing degrees of anoxia are described in the section on the function of respiration.

Cocaine. This drug has also been used as a means of obtaining release from inhibition. It was first used to set aside the catatonic stupor reaction by Berger (1921) who felt that his ability temporarily to dispel the catatonic reaction by means of cocaine was evidence in behalf of an organic origin for the condition. Since that time a number of similar investigations have been made. Moser (1922) pointed out that the procedure was not successful in all cases of catatonic stupor even though the patients might still be in the early stages of their illness. He was not able to differentiate the cases which would respond from those which would not. Fleck (1924) carried the investigation further in demonstrating that suggestion did not play a part in the results. With regard to the question of why certain cases reacted favorably and others did not he was able to do little more than restate the problem — it depends in part, he says, on the personality and in part on the stage of the illness. Bychowski (1925) pointed out that there were certain changes associated with the procedure. In particular he stated that cardiac complications might occur. Jacobi (1927), who used subcutaneous injections of 50 to 200 mg. cocaine, was able to report better contact in stupor conditions arising on varying etiological bases. He states without any very clear evidence that it is possible to distinguish purely psychogenic catatonic stupors from those arising from organic factors. More recently Buckman and Richter (1933) have shown that cocaine can set aside the bulbocapnine catatonia in animals.

Interest in cocaine was originally aroused (Maier, 1926) because of its apparent effects in reducing fatigue. Medicine first became acquainted with the drug at the time of the Spanish penetration of South America. The invading Spaniards found that it had been the custom of the Indians from immemorial times to chew the leaf of the coca shrub. This contains a large amount of cocaine. Lange (1922) has demonstrated that cocaine produces an increase in the speed of adding and also an increase in the number of errors. The time of choice reactions was decreased, and the muscular strength was increased. This was with small doses. With progressively larger doses confusion and incoordination are readily reached. Unfortunately a good deal of the psychological work has had to be carried out, because of the danger of producing addiction, either upon patients who are addicted or on those who have just been relieved of their addiction (Maier, 1926). Hallucinations following upon the administration of cocaine are quite frequently reported. For the reason mentioned and because of its rather individual action cocaine has not been used nearly so extensively as mescalin in studies of hallucinatory activity.

Bromides. The bromides belong to the group of drugs which have been employed experimentally chiefly because of their possible value in differentiating between various types of behavioral disorder. As a research tool bromides are used mainly to estimate the permeability of the hematoencephalic barrier.

The fact that substances injected into the blood stream do not penetrate into the cerebrospinal fluid in the same proportion as they are found circulating in the blood has led to the concept of a barrier between the spinal fluid and the vascular systems. The nature and location of this barrier are still a matter for speculation. It is as yet by no means agreed whether the formation of the cerebrospinal fluid is in the nature of a secretion or whether it is to be considered as a dialysate, though opinion is apparently tending in favor of the latter supposition. The barrier is naturally considered to exist at the point of formation of the cerebrospinal fluid. Opinion as to its sources is also somewhat divided, though there seems to be little doubt that the choroid plexuses play an important rôle in this. It has been shown experimentally that occlusion of the aqueduct of Sylvius results in an internal hydrocephalus and that when the choroid plexus of an occluded ventricle has been removed no internal hydrocephalus occurred.

On the basis of this fact, namely, that substances had apparently to pass a barrier before entering the cerebrospinal fluid, it was conjectured that this barrier might reveal significant changes in activity in various disorders. Various substances such as trypan blue, congo red and uranin were experimented with as standards for gauging the permeability of the "hemato-encephalic" barrier. Walters' (1925) bromide method is now considered the most satisfactory. The technique consists in the administration of 0.01g of sodium bromide in an aqueous solution per pound body weight, three times a day for five days. On the sixth day cerebrospinal fluid and blood are removed simultaneously. The proteins are removed and by the addition of gold chloride a colored compound is formed — gold bromide. These compounds are compared with one another and with known standards. A distribution quotient is obtained by dividing the blood content by that of the cerebrospinal fluid. The distribution in most individuals is found to be about three times as great in the blood as in the cerebrospinal fluid, hence the ratio is considered as 3.00. Fluctuations of 2.80 to 3.20 are considered within normal ranges.

Malamud, Fuchs and Malamud (1928) undertook the investigation of the distribution quotient in a group of 270 patients, in which were represented practically all the forms of mental disorder ordinarily encountered in a mental hospital. In none of this group of schizophrenic patients did the quotient fall below 2.8. Thirty-five per cent were between 2.8 and 3.2, and 65 per cent were above 3.2, *e.g.*, above the upper limit of normal. The manic-depressive group tended to fall within normal limits. The alcoholic cases, save those in acute delirium or recovering from delirium, also fell within normal limits. Where cerebral arteriosclerosis was present the quotient was markedly lowered. It is of interest to note that in syphilitic psychoses, where treatment had not yet been instituted or where it had been unsuccessful, the quotient was low; where it had been successful it was high. The authors state a rise in the quotient was found to be one of the best indications of the improvement in the clinical condition. The authors, in discussing the literature, note that their findings are much in line with what has been found elsewhere.

On repeating the estimations at intervals of from two to six months the authors note that the quotients never varied by more than 0.2 and that in the majority of the cases the variation was 0 to 0.1. They found no relationship between the quotient and age, sex or menstruation. Malamud and Rothschild (1931), in discussing the distribution quotient in 210 cases of schizophrenia, noted that organic disease had a disturbing effect upon the quotient. Tuberculosis acted to reduce the quotient, *i.e.*, to increase the amount of bromide in the cerebrospinal fluid relative to that in the blood. They showed this interference even more strikingly in cases in which typhoid inoculations were carried out. In these cases the quotient was again lowered. At a later recheck the quotients were found to have risen again. Very little correlation could be noted between the subtypes of schizophrenia and the quotient obtained.

There was a suggestion, however, that a high percentage of normal ratios was to be found among those patients who had shown good remissions without defect. In this larger group of schizophrenics 60 per cent showed quotients ranging from 3.20 up to 4.30; 38 per cent showed ratios between 2.80 and 3.20; 2 per cent had ratios below 2.80. The authors note that the 2 per cent with ratios below 2.80 ran rather passive decompensating types of schizophrenic processes.

Katzenelbogen and Goldsmith (1931) studied a group of 186 cases, which was composed of 67 cases of organic defect of the cerebrospinal system, 64 cases of schizophrenia, 22 cases of affective disorder and 33 cases of mental deficiency. They took as their normal limits 2.90 to 3.30. In reviewing the findings of fourteen authors they show that the general findings were to the effect that there was a low quotient in the organic psychoses, a diminished permeability in the schizophrenic psychoses, and that the manic-depressive reactions were within normal limits. Their own findings were not in complete accord with those cited. They found that in each of their four groups the permeability of the majority of the cases fell within normal limits. They found that the percentage of normal levels was strikingly high in the organic psychoses and in schizophrenia. Where dysfunction of the barrier did manifest itself, it did so in the direction of a lowered quotient in the organic group and by a raised quotient in the schizophrenic group. Age did not appear to affect permeability.

Apart from these facts which have been presented, relatively little is known of the mechanism of the barrier. The significances of the various changes is quite unclear and the whole problem is very much in the investigatory and speculative stage.

Further work has been done upon the alcoholic psychoses (Rothschild and Burke, 1933). These authors have shown that the ratio tends to fall particularly in the cases of chronic alcoholism and Korsakow psychosis. The trend was not so well marked in delirium tremens and alcoholic hallucinosis. The reason for this divergence from the results reported by Malamud, Fuchs and Malamud (1928) is not clear. It has been shown that the spinal fluid protein tends to rise the more severe the type of alcoholic psychosis (Rosen, 1940).

If it may be assumed that increased spinal fluid protein is an indication of meningeal damage, it would seem probable from what we know of meningeal permeability in organic brain states that the ratio should be lower in the more severe alcoholic psychoses than in the milder reactions.

Katzenelbogen, Goldsmith and White (1933) have studied the barrier permeability with a view to determining whether this might afford any indication of the susceptibility to bromide intoxication. They found no correlation. The effects of insulin treatment upon the permeability of the hemato-encephalic barrier in schizophrenics have been investigated (Forstmeyer, 1938; Nicolajev, 1938) without final conclusions being reached, though both authors agree that in the acute stages of schizophrenia there tends to be a lowering of the barrier. No final statement concerning barrier permeability is possible in view of the very considerable divergence of the reports from various authors. Carmichael, Rheingold and Linder (1935) could find no consistent deviation from normal in eighty male schizophrenic patients, while Masserman (1935) found the permeability high. The same author found the permeability low in general paresis. This is in conformity with the findings of most workers to the effect that the permeability is low in organic brain states.

Insulin. Certain additional information concerning lower level functioning in schizophrenia has been gained from the use of the insulin hypoglycemia treatment. An intensive investigation of the biochemical and physiological effects of this treatment and upon the differences in patients who recovered or who did not recover under this therapy has been reported by the Worcester group. It has been shown that a decrease in sugar tolerance occurs following treatment (Looney and Cameron, 1937). It has also been demonstrated that the serum lipids which, with the exception of cholesterol, are low in schizophrenia were raised in consequence of insulin treatment, this being particularly the case in those patients in whom recovery occurred (Randall, Cameron and Looney, 1938; Randall and Jellinek, 1939). The potassium, calcium and phosphorus levels of the blood showed no change save that the inorganic phosphorus level was elevated before treatment and came down to normal levels after treatment in those patients who recovered but not in those who did not recover (Looney, Jellinek and Dyer, 1939). Pulse and blood pressure studies showed that before treatment both those patients who subsequently recovered and those who did not had greater "within individual" variability of their pulse rates than normal. This was more marked in those patients who did not subsequently recover. Following treatment there was a return to normal in the pulse variability of the recovered patients but no change in the case of those who did not recover. The average pulse rate of the recovered patients rose above normal while that of the non-recovered patients stayed at normal levels. Before treatment those patients, who subsequently recovered, showed a tendency to arterial hypotension. In both groups the systolic-diastolic correlation was above normal. Following treatment the recovered patients returned to normal in all recorded aspects of the blood pressure while little or no change was observed in those patients who did not recover (Cameron and Jellinek, 1939). These findings with reference to the cardiovascular system are of special interest in view of the report by

Farrell and Vassaf (1940) to the effect that serial X-rays showed that cardiac enlargement took place in 5 out of 6 schizophrenic patients who underwent insulin treatment. Though the series is too small for any final conclusions, it appeared that the enlargement was to some extent proportionate to the degree of improvement. An increase in the systolic and diastolic blood pressures was also noted to follow treatment.

It is to be pointed out that these changes are in the main such as would occur if the adreno-sympathetic system had been rendered more active. Such a happening is quite conceivable as a compensatory reaction to the repeated administration of large amounts of insulin. It has been well known for a considerable time that insulin tends to elicit an outpouring of adrenalin which results in turn in a compensatory raising of the blood sugar level.

A similar conclusion has been reached by Gellhorn (1938) on the basis of an extensive investigation of hypoglycemia and anoxia carried out mainly on animals. He considers it probable that not only the insulin treatment but also metrazol and Dauerschlaf therapy, the therapeutic effects of inhaling high CO_2 and those following upon the administration of sodium cyanide are effective because of a stimulation of the sympathetic nervous system. We are not in agreement with this viewpoint because (*a*) the administration of adrenalin either in the usual form or linked to slowly breaking down conjugates does not produce any ameliorative effects. No therapeutic effects in schizophrenia are attributable to such sympatheticomimetic drugs as ephedrin and benzedrine; (*b*) we have increased the reactivity of the adreno-sympathetic system in schizophrenics as indicated by rise in the mean fasting systolic blood pressure and lowering of the systolic-diastolic correlation by means of daily injections of eserin carried out over periods of weeks without at the same time producing any favorable clinical change; (*c*) certain of the procedures mentioned, notably metrazol and the Dauerschlaf therapy, are successful in the manic depressive reaction though no defects comparable to those found in schizophrenia in the adreno-sympathetic system are present in this condition; (*d*) it would seem reasonable to anticipate that when recovery from schizophrenia takes place there should be improvement in the defects which characterized the condition. In essence this is simply what the activation of the hitherto inadequate adreno-sympathetic system consists in. However, it does seem important that, though repeated doses of insulin will in the non-psychotic subject produce evidence of activation of the adreno-sympathetic system, this phenomenon cannot be produced, or at best only fleetingly, in those schizophrenic patients in whom a remission cannot be attained.

A great range of reports upon lower level reactions during insulin hypoglycemia in schizophrenia is available. In most instances the work has not been done with reference to previously known defects characteristic of schizophrenia; there is in consequence no possibility of contrasting a defective aspect of the organism before and after treatment, nor has the work been set up in the main so that the lower level functioning of patients who recovered could be contrasted with that of those who did not recover. Hence the greater part of this work must be considered as consisting of studies in the action of insulin rather than as throwing any light upon the nature of the schizophrenic reaction. A similar situation obtains with reference to metrazol.

The effects of various agents in eliciting or preventing seizures and the light which they have thrown upon the convulsive response have already been dealt with in the section on that reaction.

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CHAPTER XVIII

AUTONOMIC NERVOUS SYSTEM AND ITS ADJUVANTS

Much of the uncertainty concerning the relationship between the autonomic nervous system and behavior is undoubtedly due to the difficulty in establishing a clear picture of the part which this system plays in the general economy of the organism.

The concepts of vagotonia and sympatheticotonia put forward by Eppinger and Hess (1914) now appear to have been rather premature. In general they visualized the sympathetic and vagal portions of the autonomic as being in mutual competition. Their relationship was compared to a beam balance where additional weight on the one end resulted in an overbalancing of the other but without any compensatory reaction occurring at the unweighted end. Kanner (1928) modified this to the extent that he visualized the relationship between the two components as a tug of war — extra effort on the part of the one component tended to evoke a compensatory effort on the part of the other.

The most commonly utilized concept of the autonomic nervous system is that put forward by Cannon (1915) who considers that the sympathetic division of the autonomic system has as its main function the coordination of the organism during emotional reactions and the preservation of homeostasis. Continued investigation has brought us to the point where we see that the autonomic is comprised not only of a vagal and a sympathetic division but also of several adjuvants.

In the case of the sympathetic division these adjuvants consist not only of adrenalin produced mainly by the adrenal medulla but also of one or more sympathins produced by the sympathetic nervous elements themselves during the course of their activity. These substances are probably not identical (Cannon and Rosenblueth, 1937) but are additive. Similarly the activity of the vagal division of the autonomic nervous system results in the producing of acetylcholin. The action of these adjuvants very closely resembles the action of the divisions of the autonomic which produces them but is not identical. It may also be said that in considerable measure the two components of the autonomic system and their adjuvants are antagonistic in their action. There are, however, structures which are not innervated by both components.

Cannon and Rosenblueth point out that the sympathetic and vagal divisions also differ in that the first is designed to facilitate the integrated action of a considerable number of organs and functions as, for example, in the emotional reaction or in heat control; the vagal division, on the other hand, is concerned to a greater extent with the activity of single organs and functions as exemplified by the constriction of the pupil in response to a bright light. The adjuvants of the two divisions are adapted to these characteristics. Acetylcholin produced by the vagal system is very rapidly broken down by cholinesterase. Clearly it would militate against the isolated action of the vagal system if acetylcholin produced by the activity of one vagally innervated structure remained for an extended period in circulation and thereby influenced the action of the other vagally innervated organs. On the other hand, the integrated action of the sympathetically innervated organs renders it advantageous that adrenalin and sympathin should not be broken down too rapidly. Consequently one finds that these substances may remain active in the blood stream for many minutes after they have been released.

Adrenalin. The isolation of adrenalin has led to a considerable series of investigations concerning its relationship to behavior. The demonstration that there is an outpouring of adrenalin in animals during excitement has led naturally to enquiry as to the part which adrenalin plays in the production of the emotional reaction. Maranon (1924) has claimed that the injection of adrenalin in the human subject will produce an emotional reaction in a certain number of cases. This finding has been confirmed with respect to the normal human subject by Cantril and Hunt (1932) and with respect to a group of schizophrenic, manic depressive, psychopathic and paretic patients by Landis and Hunt (1932). The latter state that, while the injection of sufficient adrenalin will produce reactions at the lower functional levels which roughly resemble those found during the emotional reaction, the experiencing of an actual emotional response is reported only by a few subjects. This problem has been discussed in the section dealing with the experimental production of an emotional response by means of injections of adrenalin (Chapter VIII).

In considering the matter it must be borne in mind that while we conventionally accept the subjective experience as a constant, if not indeed, the essential component of the emotional reaction, there are grounds for questioning this. There is now on hand evidence which suggests that the lower level components of the emotional reaction may be actively present during dreamless sleep. This, taken together with the great diversity of patterns of the emotional reaction, should render one somewhat cautious in approaching the problem of the part played by adrenalin in eliciting the emotional response.

Where a subjective component of an emotional nature is elicited by the injection of adrenalin it is frequently found that the individual was already, prior to the injection, predisposed to react emotionally or was disturbed by the severity of the lower level reactions produced by the adrenalin.

Further light has been thrown upon the problem of the relationship of adrenalin to the emotional reaction by work which has been carried out upon allied questions. Smith (1937) has shown that, though many of the lower level reactions associated with the emotional response could be elicited by means of injections of adrenalin, there was no significant effect upon the apparent resistance of the skin even though the subject reported what Smith terms the experience of a "cold" emotion. In weighing this evidence it must naturally be borne in mind that there is no agreement as to their being a complete correlation between the appearance of an emotional reaction and changes in the skin resistance.

Another indirect approach has been made by Landis (1935) who suggested that since the injection of adrenalin produced lower level changes similar to those occurring in the emotional reaction and since the latter reaction is marked by a lack of coordination of movement, it might be found that the administration of adrenalin also produced incoordination. Investigation failed to show this.

Finally Shirley (1934) has demonstrated that, even after the removal of the medullary portion of both adrenal glands in cats, these animals continued to show what seemed to be their usual behavior patterns of anger and fear when exposed to the appropriate stimuli. This behavior was also seen during the few hours that the animals survived following upon the total removal of both suprarenal glands.

Apart from these investigations into the part played by adrenalin in the emotional reaction some work has been done on other aspects of higher level functioning. Jersild and Thomas (1931) have endeavored to demonstrate the effects of 7 to 16 minims of 1:1000 adrenalin chloride intramuscularly on the ability of normal subjects to calculate, to form free associations, and to carry out certain motor activities. The capacity of the subjects to calculate was somewhat reduced by adrenalin; the ability to form free associations remained relatively unchanged, while the performance of the motor tests was somewhat improved. Lindemann (1935) investigated the effects of 1 c.c. 1:1000 adrenalin chloride intramuscularly in 48 patients. He found that, when the symptoms were those of conflict, intensification of the behavior disorder was common; in others there was either little change or a reduction in the severity of the symptoms. Lindemann and Finesinger (1938) have studied the effects of 1 c.c. 1:1000 adrenalin chloride intramuscularly upon the behavioral responses of a group of patients suffering from anxiety states. They found that actual anxiety attacks could be elicited in six of the twenty patients whom they investigated, and that the anxiety attacks thus produced were characterized by self-absorption and withdrawal. Moore and Cameron (1938), working with normal subjects and using 0.5 c.c. 1:1000 adrenalin chloride, found great individual variation in higher integrative functions. This was particularly marked in connection with the organization of the responses to the ink blot test. Considerable individual variability was also noted in respect to the reaction time tests.

The relationship of adrenalin to behavior has been considered in some detail since it seems probable that further advances in this field may ultimately afford us greater insight into the temporary distortions of thinking which occur in anger and panic states and into those more extended distortions, frequently amounting to actual projections, which one finds in states of agitated depression.

Lower Level Responses. In addition to this interest in the effects of adrenalin upon higher level functioning, work has been carried out upon the influence of adrenalin upon lower level functions in several of the abnormal reaction types. This work has been almost entirely confined to the response of the blood pressure and the blood sugar.

The earlier work in this field suffered from the defects which have until recently tended to characterize investigations into the lower level functions of individuals suffering from abnormal behavioral responses. These defects in brief are the use of single observations on a group of patients rather than multiple observations and a failure to state precisely not simply the reaction type but also the intensity and phase of the reaction as well as such other important facts as the sex, age and general health of the individual.

The earliest work on the response to adrenalin of the blood pressure in schizophrenia is that of Schmidt (1914) who stated that intramuscular injection of 0.5. mg. adrenalin chloride preparation was followed by a much more limited blood pressure response in the schizophrenic group than is found in the normal control group. This was particularly marked in the case of the catatonic and hebephrenic patients. Similar results were reported by Neuberger (1915) who suggested further investigation of the effects in the psychotic group of adrenalin in dilating the pupils and producing blood sugar rises. Considerably further progress was achieved with greater knowledge of the various types of blood pressure curve which followed on injections. Kanner (1928) followed the blood pressure response to the subcutaneous administration of 1 c.c. 1:1000 adrenalin chloride at frequent intervals over a period of 70 minutes. His case material consisted of 34 schizophrenic and 9 manic-depressive patients. In all the schizophrenic patients he found what he considered a vagotonic type of curve. This consisted in either an immediate drop in blood pressure following upon the administration of the adrenalin, or a slow rise starting several minutes after injection, or in a rise which, while starting at once, was definitely less than normal. The intensity of the vagal response was correlated not with any subtype of the disorder but with the degree of apathy. The more marked the indifference of the patient the more marked was the vagal response. All those patients who suffered from a manic-depressive reaction gave a sympatheticotonic form of response — a rapid rise of 40 to 60 mm. Hg. — with the exception of three depressive stuporous patients in whom a vagotonic curve was obtained.

Further refinement of technique was achieved by Freeman and Carmichael (1935) who, in addition to taking precautions to obtain basality and freedom from intercurrent disorders, administered the preparation by the intravenous route. Their material consisted of 72 male schizophrenic patients and 24 normal controls. The dose used was 0.05 mg. adrenalin chloride and pulse and blood pressure readings were taken frequently over a 30 minute period. They found that the mean rise in systolic pressure in the schizophrenic group was 43.8 mm. Hg. and in the normal controls 56.2 mm. Hg. The difference was statistically significant. The changes in the diastolic pressure were variable. There was a greater tendency for the patients to react by a rise in the diastolic pressure. It is of interest to note that the mean rise in pulse rate in the schizophrenic group was 13.6 beats per minute while in the control group the rise was 16.3 This difference was not, however, statistically significant. Kraines and Sherman (1940) have followed a similar procedure with respect to a group of twenty-five psychoneurotic patients and nineteen normal controls. The amount of adrenalin chloride injected was 0.01 mg. They found that the pulse and blood pressure responses of the two groups could not be differentiated and that the symptoms of the patient group tended to be accentuated. The types of psychoneuroses shown by this group were not recorded so that it is not possible to tell whether those patients who suffered from anxiety neuroses showed a more marked response as the work of Lindemann and Finesinger, discussed earlier, might suggest.

The blood sugar response to administration of adrenalin has been investigated in several of the abnormal reaction types. In the normal individual the administration of adrenalin produces a rise in the blood sugar due to release of glycogen stored in the liver. Raphael and Parsons (1922) administered 1 mg. adrenalin chloride intramuscularly to a group composed of 9 schizophrenic and 6 manic depressive patients. They found that the general contour of the blood sugar curve agreed fairly well with that shown by normal subjects save that after the first three and a half hours the level of the sugar in the blood continued to drop below normal in the depressed and schizophrenic cases. Gordon, Ostrander and Counsell (1927) worked with a small group consisting of 1 schizophrenic and 5 manic depressive patients. They injected 5 minims 1:1000 adrenalin chloride subcutaneously and withdrew blood at 15 minutes, 45 minutes, and 1¾ hours. They found in the manic-depressive cases a well defined peak and a delayed return to the fasting level; the one schizophrenic patient showed a less well defined peak and a less marked delay in returning to the fasting level.

Schultze-Bünte (1936) investigated the blood sugar, pulse and blood pressure responses of 12 schizophrenic patients to the subcutaneous injection of 1 c.c. 1:1000 adrenalin chloride. The blood sugar curves taken over a period of 120 minutes were striking because of their variability. No deviation from normal could be noted in the pulse and blood pressure responses. These results should, however, be accepted with reserve since the type of schizophrenic reaction was not clearly stated. Moreover this procedure shares with that advocated by others a serious defect arising from the fact that the blood sugar level cannot fail to be affected by the taking of numerous blood samples. In this instance 9 were taken within a period of 120 minutes. Dynes and Tod (1940) investigated the blood sugar and general behavioral response of a group of 10 deteriorated schizophrenic patients and a normal control group of 6 patients from a general surgical ward to the intramuscular injection of 0.5 to 1.0 c.c. 1:1000 adrenalin chloride. Their findings agreed with those obtained by the majority of workers in that they showed that the blood sugar response to the injection of adrenalin in the schizophrenic group did not differ from the normal control group save that there was considerably greater variability. The behavioral response of the schizophrenic group, however, did differ markedly from that shown by the normal controls. The latter all expressed anxiety, tension and apprehension. In contrast the schizophrenic patients, while evincing the same evidence of palpitation, trembling and pallor, made no statement indicating emotional disturbance. While the authors feel that this denotes the existence of a disturbance of the emotional mechanism at the physiological level some doubt must remain as to whether it may not rather be an indication of the reduction in communication and social responsiveness which is a well recognized component of the schizophrenic reaction.

Acetylcholin. In contrast with adrenalin little work has been done upon the effects of acetylcholin upon behavior. Among other reasons it should be recalled that the vagal component of the autonomic system is organized to control the single activity of organs and functions rather than to produce an integrated response as does the sympathetic division. Consequently profound effects upon behavior are rather less likely to follow upon the activity of the vagal division. A further reason consists, naturally, in the fact that acetylcholin, the vagal adjuvant, has been more recently isolated than adrenalin. Finally we should emphasize the fact that it is much more rapidly broken down in the organism.

Jones (1936) made use of carbaminoylcholin chloride which has an action similar to that of acetylcholin in that it stimulates the parasympathetic nervous system. He found that, in 6 patients suffering from attacks of acute anxiety, observation indicated that there was considerable relief from the anxiety at the end of two weeks after treatment by carbaminoylcholin had been initiated.

Misch (1938) has reported that the administration of a preparation of acetylcholin to a series of patients suffering from anxiety attacks has resulted in disappearance of their symptoms. He postulates an overactivity of the sympathetic division during the attack, this being overcome by the increased activity of the vagal division under the influence of the acetylcholin. These findings still await confirmation. Lindemann and Finesinger (1938) have made use of mecholyl (acetyl-betamethylcholine) to study the responses of patients suffering from anxiety states. They found that it was possible to elicit typical anxiety attacks in 5 out of 20 patients by means of injecting 5 to 25 mg. mecholyl intramuscularly. The behavior shown during these attacks was distinguishable from that shown during attacks elicited by means of injections of adrenalin by the fact that there was good contact, readiness to talk and lively attempts at rationalization.

Sympathetic Division. This portion of the autonomic nervous system has as its main functions the preservation of homeostasis and the preparation of the organism for emergencies. The activities of which these functions are comprised are numerous. Many of them have already been discussed. This applies particularly to the changes which occur in the preparation for emergency — these are discussed in the section on the facilitative functions. The galvanic skin reflex activities are dependent upon the autonomic nervous system, and they have been described in the section on electrical phenomena. Similarly the pulse, blood pressure and circulation time responses have been considered in the section upon the oxidative functions; the respiratory activities are also discussed in the same section. In summary it may be said that the greater part of work on these aspects of the activity of the sympathetic division of the autonomic system has shown that there are few primary abnormalities present save in the schizophrenic reaction. Numerous workers have agreed that at least in those patients who have shown progression in their schizophrenic reaction, there tends to be a slight lowering of oxygen consumption, a slight lowering of pulse and blood pressure. In addition the correlation between systolic and disatolic pressures tends to be higher than normal. The circulation time is prolonged, and the respiratory center is rather less sensitive. The findings with respect to the galvanic skin reflex are less clear-cut in schizophrenia. It will, of course, be borne in mind that these statements are made with respect to abnormalities originating in all probability within the sympathetic division itself or possibly in respect to its adjuvants. Abnormalities arising elsewhere, such as pathological anxiety states, certainly manifest themselves through the autonomic nervous system; but evidence is lacking that these states are to be referred primarily to this division.

Further evidence concerning the activity of the sympathetic division in the schizophrenic reaction has been reported by Pfister (1938) who investigated the cardiovascular responses of normals and patients to the assumption of the erect posture. He also investigated the responses of these two groups to hot and cold stimuli and to the application of irritants to the skin. These data lead him to suggest that in the early acute stages of the schizophrenic reaction there is a hyperexcitability of the sympathetic division and that, as the reaction progresses toward chronicity, this reactivity gradually becomes less and finally the reactions of the sympathetic division become both more sluggish and more variable than normal. Freeman and Rodnick (1940) have studied the adaptive reactions of the cardiovascular and respiratory functions in 31 normal controls and 29 schizophrenic patients. In order to put these functions under stress they had their subjects inspire oxygen the temperature of which had been raised to 41° C. and the humidity to the point of saturation. By this means heat loss through the lungs was prevented, thus throwing strain upon the rest of the heat control mechanisms. The reactions of the normal control group were considerably more active than those of the schizophrenic patients. This suggests that reactivity of the sympathetic division is more sluggish in the schizophrenic patient. Further data on this point have been reported by Rodnick and Shakow (1940) who have shown that the schizophrenic patient is not able to hold himself so long "set" for a response to a reaction which he is to be called upon to make as is the normal individual. These workers made use of the galvanic skin reflex as their indicator.

Among the major activities subsumed under the designation homeostasis are those which are concerned with heat control. As indicated above, the other activities have been discussed in earlier sections. Cameron (1934) investigated the temperature regulatory system in 50 schizophrenic patients using as controls a group of 50 psychiatric patients not suffering from schizophrenia. He showed that the mouth temperatures of the schizophrenic group were slightly lower than those of the non-schizophrenic group. Temperatures were recorded throughout the day. On exposure to extreme cold the response of the schizophrenic group was more active than that of the control group. No evidence of failure was noted on exposure of the schizophrenic group to high room temperatures. Carmichael and Linder (1934) carried out a similar investigation using normal controls. They report that the schizophrenic had a higher oral temperature and essentially the same rectal temperature as the normal control group. Following upon more detailed statistical analysis of their data Linder and Carmichael (1935) report that the mean difference for the oral and rectal temperatures is less for the patient than for the control group and that these oral and rectal temperatures are more highly correlated in the patient than in the control group. This latter point is of interest in view of the high correlation found between the systolic and diastolic blood pressures in the schizophrenic group and the fact that it has been considered as indicating a relative inactivity of the sympathetic division. Gottlieb and Linder (1935) exposed schizophrenic and normal control groups of patients to an elevated room temperature and found that the mouth and rectal temperatures of the patients rose more rapidly than did those of the control group. They confirmed the earlier finding with relation to the close correlation between the mouth and rectal temperatures. Freeman (1939) has improved the technique in this field considerably by carrying out his investigations in a laboratory in which the humidity, temperature and speed of air movement can be rigidly controlled. Moreover, all his patients were investigated in the nude. He found that exposure to cold resulted in a more rapid heat loss in the schizophrenic group and that exposure to elevated temperatures failed to show any definite difference between the two groups. His findings were with respect to rectal and skin temperatures. In considering these latter findings with relation to the earlier report of Cameron, a possibility of reconciliation consists first in the fact that the latter was contrasting a schizophrenic with another psychotic group while the other workers used normal controls, and secondly, that the patients upon whom he worked were in the acute stages of their illness while those investigated by the other workers were for the most part deteriorated. This point should be considered in the light of the statements of Pfister (1938), discussed above, to the effect that the sympathetic division is hyperactive in the early stages of the schizophrenic reaction and sluggish in the deteriorated stages. The work of Ziegler and Cash (1938) upon the effects of emotional disturbance upon the heat control system belongs to the problem of the emotional reaction rather than to the autonomic nervous system. It has been considered in the section dealing with that reaction.

Vagal Division. As indicated in the consideration of acetylcholin, the amount of work done in this field is considerably more limited than is the case in regard to the autonomic division. The nature of organization of the vagal division seems likely to preclude the possibility of such widespread lower level activity as would be likely, by its mere extensiveness, to produce behavioral change. A considerable amount of rather speculative material has nevertheless been reported concerning the activities of this division of the autonomic nervous system. This is exemplified by the viewpoints of Horsters (1938). He states that in the child there is a more definite trend toward vagotonia and in the adult toward sympatheticotonia; in summer the individual is more sympatheticotonic and in winter more vagotonic. Supporting data for these assertions are scanty and indeed the point of view shows evidence of being influenced by earlier, now largely discarded, concepts of the autonomic nervous system. A considerably more factual account of the problem is furnished by Galowina and Wopilkina (1934) who followed pulse, blood pressure, pupillary findings, degree of sweating and other indices in 9 catatonic stupors over a period of 1½ years. They state that their patients showed that the pulse was slower than normal and the blood pressure was low. Both of these indices rose on recovery. There was red demographia, with cyanosis of the extremities. Increased sweating and salivation were noted. There was also increase in the muscle tonus and the skin was greasy. The authors point out that these findings cannot be arbitrarily referred to abnormalities of either the sympathetic or vagal division but that the picture is rather one of a profound disturbance of the whole autonomic nervous system.

As indicated in the section upon acetylcholin, Hess (1932) has suggested that the vagal division is primarily involved in the mechanism of sleep. The evidence which he advances to substantiate this point of view is not impressive. Apart from his own experiments on the effects of injecting ergotamine into the third ventricle, he cites the constriction of the pupils during sleep, and experiments of Koch (1932) on the effects of stimulation of the carotid sinus in animals. An inhibitory state closely resembling sleep was elicited and the parasympathetic tone simultaneously increased. Further confirmation of this viewpoint is required.

Considerable difficulty in the detailed investigation of the vagal division has been occasioned by the fact that the means of integrating its activities are considerably more limited than is the case in the sympathetic division. The study of the sugar tolerance curves (Kanner, 1928) has already been considered in this section. The study of the hemoclastic crisis (Widal, Abrami and Iancovesco, 1920) was used extensively by Robertson (1926) in an attempt to investigate defects of the autonomic nervous system in schizophrenia. Since it was shown by Yates and Batt (1932) that the method contains a very high technical error, it has been little employed.

The use of such drugs as pilocarpine and eserin has done little further to advance our knowledge of the relationship between the activity of the vagal division and changes at the behavioral level. A similar statement may be made with reference to the oculocardiac reflex. In the normal individual moderate pressure on the eyeballs results in a drop of 5 to 10 beats per minute in the heart rate. In individuals, in whom the vagal division is particularly active, the degree of drop is said to be greater. This method was used by Claude, Santenoise and Targowla (1925) in a detailed attempt to establish what they termed a biologic diagnosis of states of excitement and depression. The findings were in no way clear-cut. While the workers report that they found in general that mental states which were periodic in type were also characterized by hyperactivity of the vagus one notes that they also report that manic excitements which are accompanied by anger are usually associated with marked sympatheticotonia. Jones (1936) made use of the oculocardiac reflex as a means of determining whether he had been successful in overcoming the severe sympatheticotonia of his anxiety neurotics by means of the administration of acetylcholin (doryl). The six patients showed, subsequent to treatment, from 3 to 40 per cent greater slowing of their pulse rate in response to pressure on the eyeballs.

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CHAPTER XIX

ENDOCRINE FUNCTION

The relationship of endocrine activity to behavior is at present quite imperfectly worked out. For reasons which are not yet clear the development of this field has been accompanied by an unusual amount of unwarranted speculation. A possible explanation may lie in the fact that the problem of the relationship of behavior to endocrine function focused the attention not only of endocrinologists, but also of biochemists, psychologists and psychiatrists. While the workers in each of these groups naturally had competence within their own fields very few had had a sufficiently comprehensive training to deal with a problem which extended over so wide a range of human functioning. Thus one finds that the endocrinologist frequently ignores entirely the psychosexual organization of the individual whom he is studying and acts as though the sex hormone which he is administering were actually sex activity in tablet form. Similarly, one finds that the psychologist and psychiatrist only too often disregard problems of assay and problems of the interrelated action of the various endocrine glands. Moreover, the development of this field has also suffered from attempts to apply in a too sweeping manner the information gained from animal experimentation to problems of human behavior. In late years there has been increasing recognition of these difficulties, and the experimental approach to the problems of the effects of the endocrines on behavior has been modified in accordance. Furthermore, there has been growing appreciation of the fact that there are difficulties in considering even the integrated action of the whole endocrine system as a unit. Its inter-relationship with the autonomic nervous system is acquiring recognition. One of the most useful of the current concepts of endocrine function is that these glands have an action analogous to that of the nervous system. They control activity and growth but the stimuli which they transmit are much longer acting and achieve their results much more slowly than do those transmitted by the central nervous or autonomic nervous systems.

Thyroid. The fact that we have been able for some time (Kendall, 1918) to produce the active principle of this gland in reliable form and the fact that we possess in the basal metabolism technique a means of estimating at least in general terms the effects of thyroid in the living organism have resulted in our acquisition of a certain amount of data concerning the relationship between human behavior and the activity of the thyroid gland.

Since the administration of thyroid increases the rate of metabolism, the question has naturally been raised whether there is also an increase in the activity of the organism. This matter has not yet been satisfactorily settled. Removal of the thyroid gland in rats results in a considerable reduction in activity, this reduction being however interspersed with occasional bursts of hyperactivity (Richter, 1933). The administration of extracts of the gland to normal rats has not resulted in any increase in activity which could be measured by the means available. In many instances the animals eat and drink enormously but actually become less active. With regard to the human organism few data are available. It is of course known that patients suffering from myxedema tend to be inactive and slow in their movements while those individuals who develop an exophthalmic goiter are, while not overactive in the manner of a hypomanic reaction, fidgety, restless and jerking in their actions. The administration of large amounts of thyroid extract (up to 36 grs. daily) in a group of deteriorated schizophrenic patients (Cohen, 1939) resulted in a general increase in activity. This activity was directed into special pathways in certain cases, for example, some patients busied themselves excessively in dressing or in masturbation. It is of interest to note that a small number of the patients showed, at the time when they were receiving full doses of thyroid, a tendency to pass into torpid states. This requires further consideration in connection with the catatonic reaction. There are good reasons for considering that the catatonic stupor is not a passive reaction but is maintained by the expenditure of considerable energy. It has been shown, on the other hand, that the maintenance of cataleptic postures is achieved with considerably less evidence of effort than is the maintenance of similar postures by the normal subject. (*See* section on Sleep and Allied Reactions.) These facts raise the question whether the production of these torpid states in schizophrenic patients in response to great increase in metabolic rate may not furnish further evidence of an abnormality in the mechanism whereby energy is utilized. These observations should also be considered in the light of Richter's (1933) findings in rats. These have been discussed earlier.

The action of thyroid upon the learning process has been largely studied in animals. Borovski (1931) found that guinea pigs fed upon thyroid extract learned choice reactions more rapidly than did a control group. This greater capacity was lost, however, if an interval was introduced between the stimulus and the possibility of reaction. The author suggested that nervous restlessness of the thyroid fed animals tended to break up the pattern of response. Watanabe and Nomura (1936) also found that rats fed upon thyroid extract were more restless than the controls and tended to learn to run mazes more rapidly.

The effect of thyroid upon the conditioned reflex has also been studied and since the information derived from this has some bearing upon the learning process it is to be considered at this point. Asimoff (1928) has investigated the effects of extirpation of the thyroid gland upon the activity of conditioned reflexes in dogs. He found that, while the conditioned stimulus produced the conditioned reflex with equal rapidity in the control and operated dogs, the strength of the conditioned response was greatly reduced in the animals which had been deprived of their thyroids. Moreover, it was much more difficult to obtain a subsequent conditioned reflex in the operated dogs than in the controls. He quotes Schastima as having made similar observations in myxedematous children.

Zawadovsky and Sack (1928) found that administration of thyroid to dogs produced, after a preliminary depression, an increased activity of conditioned reflexes. The latent period was shortened and the conditioned reflex was considerably increased. There was also an increase in the capacity to differentiate between conditioned stimuli. Kleitman and Titelbaum (1936) studied the later phenomenon and confirmed the findings of Zawadovsky and Sack. In their animals there was an increased capacity to differentiate both positive and negative conditioned stimuli during the period over which thyroid was being administered. In the thyroid-free period there was a definite slump in the capacity to differentiate.

Reference was made earlier to the "nervousness" reported by Borovski (1931) as occurring in guinea pigs which had been fed thyroid extract. These symptoms — nervousness, irritability, restlessness — are widely reported as resulting from the administration of large amounts of thyroid. For this reason thyroid has been used in an attempt to sensitize persons on whom experimental injections of adrenalin were being carried out in order to study the emotional reaction. The results have not been any more clear-cut than those resulting from simple injection of adrenalin. (*See* section on Adrenalin.) In line with this finding is the point of view expressed by Brown and Gildea (1937) who suggest that there is a constitutional predisposition to hyperthyroidism which consists in the first instance in what they term a sensitive thyroid gland. They also posit a feeling of insecurity, a strong sense of responsibility and a failure to express emotional reactions. Whether these are to be considered as arising from the original sensitivity of the gland or not is unclear. It is suggested that the final development of hyperplasia arises from severe emotional strain to which such persons would be particularly liable.

During the earlier discussion of Asimoff's (1928) investigation on the effects of extirpation of the thyroid upon the conditioned reflexes, it was pointed out that the speed of appearance of the conditioned reflex was the same in operated and control animals. This is of interest in view of reports (Gardner, 1935) to the effect that the estimation of time in the human subject cannot be correlated with various types of disorder of the thyroid gland or with the B. M. R. in persons suffering from such disorders. The pulse rates in the group under investigation ranged from 114 to 80 and the B. M. R. from + 25 per cent to − 11 per cent. At first sight these would appear to conflict with the fact that the estimation of time has been found to vary with cardiac and respiratory rates. An explanation of this apparent divergence may lie in the fact that the experiments on the effects of variation of the cardiac and respiratory rates upon the estimation of time have usually been carried out in the acute situation. The rates have been raised abruptly by fever or exercise. In the case of Gardner's studies the abnormal pulse and B. M. R. rates had been present over a prolonged period of time, and it is possible that a readjustment of the estimation of time had been made on this basis. Similarly, though Asimoff does not give full details of the time which elapsed between extirpation of the thyroid gland and the establishment of the conditioned reflex, in the case of one dog the interval was seven months.

In spite of the apparent specificity of thyroid in cretinism the amount of work upon the behavioral aspects of the problem is rather disappointing. This must be attributed, in part, to the fact that means of precise estimation of personality traits are still quite inadequate. The main emphasis in this field has been upon the alterations in structure, the metabolic changes and the status of the intelligence quotient following upon the administration of thyroid. Some careful studies of behavior by means of the observational method have been made, notably by Gesell, Amatruda and Culotta (1936). These workers found that the structural and metabolic disorders in cretinism could be much more satisfactorily corrected than could the disturbances at the behavioral level. They note that even where a reasonably good intellectual level was attained some degree of the docility and placidity characteristic of the cretin tended to remain. Moreover, these workers were unable to state any criteria which could be used to determine in advance which of a group of cretins would respond adequately to treatment. The only realistic test is the therapeutic. Those who will respond most adequately do so early in the treatment and do so in response to small doses of the extract. Complete return to normal behavior is possible even where the cretinism has been quite pronounced (Lewis, Samuel and Galloway, 1937). The fact that this is by no means the rule may be accounted for in part by the fact that cretinism is at times associated with other conditions such as Little's disease or mental deficiency not due to the thyroid defect. Further, it seems probable that, when the cretinism has been allowed to persist for many years before thyroid treatment is initiated, secondary irreversible changes in cerebral functioning may occur. It is of interest to note that certain of the behavioral changes associated with cretinism and myxedema, namely, poor recent memory, limited span of attention, emotional instability (at least in the case of myxedema), and slow cerebration are similar to those changes found in consequence of chronic anoxemia and also similar to those found in the senium. This is to be considered in the light of our knowledge of thyroid as an oxygen catalyst.

In spite of the fact that myxedema is associated with abnormalities of behavior — dullness, psychomotor retardation, fatigability, depressive and delirious states (Akelaitis, 1936) — which may become extreme, very little experimental work has been done in this field. Mention has already been made of Asimoff's (1928) studies of dogs deprived of their thyroid gland. The brain potentials in myxedema show slowing of the alpha frequency and diminution of amplitude (Bertrand, Delay and Guillain, 1938). This finding is reasonable in view of the fact that increase in cerebral metabolism is known to be associated with increase in the alpha frequency. Rubin, Cohen and Hoagland (1937) have shown that there is a definite rise in alpha frequency in schizophrenic patients who are receiving thyroid, and Ross and Schwab (1939) have found a positive correlation of 0.688 between alpha frequency and B. M. R. in a group of 12 myxedematous and 22 hyperthyroid patients.

The behavioral reactions associated with hyperthyroidism have not yet been reduced to experimental terms. There is in existence a considerable body of sound observational material upon these states and a still more considerable body of speculation. The latter has particular reference to the possibility that hyperthyroidism may arise solely or in part from emotional trauma. The reactions produced by the administration of thyroid have already been considered at the beginning of this section.

The relation of thyroid activity to abnormal behavioral reactions has been studied fairly exhaustively. The means adopted are, however, not altogether adequate. In most instances they consist in investigations of the B. M. R. and in studies of the clinical symptoms shown by the patients. The latter method has shown itself to be quite incapable of revealing any but gross abnormalities of thyroid functions such as do not exist save as concomitant conditions in the abnormal reaction patterns. The estimation of the B. M. R. provides a much more sensitive measure of the degree of thyroid abnormality. It is necessary, however, to bear in mind that the metabolic rate can be affected by other agents than the thyroid gland. This criticism is particularly important in the case of schizophrenia. The majority of workers (*see* section on Oxidation) are agreed that the B. M. R. in schizophrenia is below normal and it has been suggested that this may be due to a defect in thyroid function. Another possible explanation may lie in the fact that the autonomic nervous system (*see* section on Autonomic Nervous System) is known to be sluggish in schizophrenia.

Further evidence for a possible defect in thyroid function consists in the fact that thyroid patients are apparently able to tolerate large doses of thyroid (36 grains daily, Cohen, 1939). Whether this is a larger dose than could be tolerated by the normal subject is not known; similarly it is not known whether the sluggishness and insensitivity of the autonomic nervous system which exists in deteriorated schizophrenic patients renders it possible to assimilate these large doses of thyroid without undue metabolic reaction.

Hoskins and Sleeper (1930) consider that thyroid deficiency plays a significant part in about 10 per cent of schizophrenic patients admitted to hospital and that the administration of the hormone is of value in carefully selected cases. The work of Gjessing (1939) on catatonic stupor has already been considered. (*See* section on Stupor.) He found that fluctuations in nitrogen retention occurred in patients liable to alternating stupor and excitement. The administration of thyroid to these patients served both to control the nitrogen retention and the stupor reaction. It is well to recall that the catatonic stupors represent about 2 per cent of the total number of schizophrenic patients admitted to hospital. There is no evidence that deviation of thyroid functioning consistently accompanies any of the other abnormal reaction patterns.

Adrenal Glands. The relationship of the secretion of the medullary part of this gland to behavior has already been considered in the section on the autonomic nervous system and its adjuvants. The various hormones produced by the cortical portion of the adrenal gland are for the most part still under preliminary investigation. Removal of the cortex in animals, unless means are provided to keep up the fluid and salt intake, results in speedy death. The action of cortin on behavior has not yet been adequately studied nor do we know with any precision what influence the adrenal cortex exerts on human sex behavior.

Gonads. The relationship of the activity of these glands to variation in behavior has been extensively considered. The experiments of Brown-Séquard (1889) on the effects of subcutaneous injections of gonadal extracts, the pathological studies of Mott (1920) upon the ovary and testicle in schizophrenia, and the attempts of Voronoff (1922) to transplant grafts of testicular tissue have served greatly to increase the interest in this field quite apart from the fact that the claims of these investigators have found only limited substantiation in the intervening years. The work upon the relationship between sex endocrine function and behavior has naturally received further stimulus from the emphasis placed upon the sex life of the individual by Freud.

Since it is, of course, informative not only to study the effects of the administration of sex gland extracts but also to investigate the results on behavior of removal of the sex glands much of the work in this field has been carried out on animals. Before considering the evidence obtained by this means it is desirable to clarify the degree to which these data are applicable to the human subject. The lower the animal in the vertebrate scale the less applicable to the human organism is the information obtained by this means. It would indeed appear that, at least as far as their responses to endocrine activity are concerned, the behavior of the lower animals becomes increasingly automatic the further we descend the vertebrate scale. The great development of the higher functional levels in man has rendered possible an infinitely greater variety of response. This fact is particularly apparent in his behavioral response to variations in sex endocrine activity. Indeed the fact that social living has laid such restrictions on the manifestations of the simple sex urge and has resulted in its appearance in so many substitutive and secondarily related forms of sex activity tends still further to diversify the possible behavioral reactions to variations in sex endocrine activity.

Castration. In the lower animals the effects of this procedure are relatively clear-cut. In the rat the total daily activity is definitely reduced (Gans, 1927; Slonaker, 1930). In this connection it is of interest to note that most workers agree that there is no reduction in learning capacity in castrated male rats (Tuttle and Dykeshorn, 1928; Commins, 1931, 1932). These observations are of particular interest in view of the relationship which exists at least in the lower animals between activity and learning.

The effects of castration on the sexual behavior in lower animals depends to some extent upon whether it has been carried out before the adult sexual patterns have been established or afterward. In the former case no sexual behavior appears even when the animal reaches an age at which sexual activity is normally well developed. If castration is carried out after the pattern has been well established it may persist in varied degree for periods which are dependent to some extent upon the species (Stone, 1923).

The effects of castration upon human behavior are much less clearly known. At present there exists no means of assessing objectively the total activity of the human organism. Observation as to the activity of those castrated before or after puberty has yielded varying reports. According to some workers eunuchs are generally inactive and indolent. This statement is hard to reconcile with the fact that in former cultures such individuals frequently enjoyed positions of great responsibility. Castration in the human subject does not adversely affect the learning capacity. Detailed studies, however, are lacking. One of the more extensive is that carried out by McCartney (1929) upon 23 Chinese eunuchs.

The effects of castration upon the sexual behavior of human beings is considerably more varied than is the case in the lower animals. At the outset it is necessary to make some differentiation between the maintenance of desire and the persistence of potency. By the latter term is understood the capacity to effect erection, intromission and orgasm. It appears probable that though both desire and potency quite frequently persist after castration the former tends to be less affected than the latter. From the various clinical reports available it appears that the sex drive is decreased to an extent which depends both on the age at which the procedure is carried out and also upon the intensity of the drive prior to operation. When castration is carried out before the adult sex pattern has been established the probability that the individual will show adult sexual activity in later years is considerably less than is the case when castration takes place after a well defined sexual pattern has been set up.

Castration has been advocated as a means of dealing with patients having a sex drive of such intensity as to constitute a social danger or in those in whom serious types of perversion are present (Hackfield, 1935; Wolf, 1935). In view, however, of the frequent reports to the effect that perversion is particularly common in eunuchs it seems wise to suspend judgment concerning the efficacy of this procedure.

Effects of Substitution. The earlier work in this field was of necessity carried on in connection with grafts. In the last three years, however, a synthetic male sex hormone, testosterone propionate, has been produced and the emphasis has now come to be placed on this method of approach rather than upon the use of grafts. The latter procedure was first employed by Berthold (1849). This worker was able to transplant testicular tissue into capons with the production of growth of the comb. Brown-Séquard (1889) reported rejuvenative effects following the injection of testicular extracts both in lower animals and in man. This was followed by attempts on the part of numerous workers, among them Voronoff (1922), to effect transplantation of testicular and ovarian substances as a means of overcoming senile changes. The ligation of the vas deferens was worked out as a means of indirect activation of those testicular cells which produce the internal secretion of the testis. Though occasional good results have been obtained progress in this field has been greatly obscured by baseless speculation and unwarranted claims. These have appeared the more readily since the psychologists have been unable to produce reliable objective techniques for the estimation of sex activity.

Direct observation has been of use in affording information in regard to the effects of the administration of male sex hormone in the lower animals, but in man a considerable amount of reliance has to be placed upon the report of the individual. Unfortunately, the knowledge that he is being treated by means of a sex hormone and the frequent questioning concerning his sex experiences tend to increase his sex awareness and thus distort his report.

It seems probable that testosterone propionate is capable of restoring more or less completely the sex activities in castrated lower animals such as rats (Stone, 1939). It also seems probable that the effects of this hormone on the activity of senile rats is limited (Korenchevsky and Hall, 1939). These workers point out that there was no indication that the testicles in their senile animals had shown undue atrophic changes.

In the case of the human subject there are several clinical reports to the effect that the administration of testosterone propionate has restored in large measure the sex activity of castrates in whom there had been little or no remaining sexual capacity (Miller, Hubert and Hamilton, 1938; Kearns, 1939). With this return in sexual capacity there was also noted a subsidence of many of the behavioral characteristics formerly shown by these castrates. They became more active and aggressive; feelings of inadequacy and depression subsided. Some work has been carried out upon the effects of this male sex hormone in individuals showing abnormal behavior reactions. The reports are still contradictory, and it is clear that we are yet in the exploratory stage as far as this field of behavior is concerned.

While there is ample evidence that deficiency of the male sex hormone may be associated with the appearance of abnormal behavior as is often the case in complete castration, there is little indication that the major abnormal reaction types are associated with consistent deviation in sex endocrine function. The work of Mott (1920) has never been adequately confirmed. (*See* section on Structural Functions.) A number of studies such as that of Gibbs (1923) based upon size of testicle, distribution of hair and general body outline have been made. It seems probable that the secondary sex characteristics in persons prone to behavioral breakdowns tend to be less normally developed than in the average population, and it also seems probable that this is more frequent in the schizophrenic reaction. It is, however, quite impossible to proceed from these observations to a statement that any of the major abnormal reaction types are associated with a specific form of sex endocrine defect. Possibly a more definite working out of this field will be feasible with the assistance of the methods now being developed for assaying the actual potency of the sex hormone in the living subject.

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CHAPTER XX

ENDOCRINE AND VITAMIN FUNCTIONS

Female Sex Hormones. What has already been said in introducing the problem of the relationship between the male sex hormone and human behavior may also be said with reference to the interrelationships which exist between the activity of the female sex hormones and the behavior of the human organism. The information which is derived from animal experimentation cannot be applied without considerable qualification to the field of human behavior. This is particularly true of women since social usage demands an even greater degree of qualification and secondary elaboration of the primary sex urge in their case than it does in men. Furthermore, the lack of exact means of estimating sex behavior in the human subject operates here as in the case of men to render quite tentative our statements regarding the effects of variations in sex endocrine activity upon behavior.

Castration. In lower animals this procedure results in certain well defined behavioral changes. Of these the most striking is the loss of sexual receptivity in those animals which lie below the level of monkeys in the scale of vertebrates (Commins and Stone, 1932). In attempting to transfer this observation to the human field it must be borne in mind that the great majority of lower animals are receptive only during their period of "heat." This period appears to be linked up with the stages of the estrus cycle though the precise correlations are still uncertain. It may, however, be stated quite definitely that with the disappearance of the estrus cycle after castration in the lower animals the phenomenon of "heat" also disappears. In the human subject, on the other hand, there are only remnants of a relationship between the phases of the estrus cycle and sexual receptivity. The latter, save for the periods of menstruation, is practically continuous throughout the child-bearing period and for a variable time beyond it. Indeed, there are several reports to the effect that sexual desire, in certain individuals, may be strong even during the period of menstrual flow.

A second major result of castration of females in the lower animals is a considerable reduction in activity (Wang, 1923). This worker was able to show not only that the total activity of female rats dropped to a marked degree following upon castration but he also demonstrated by means of the revolving cage procedure that there was a great increase in activity when the rat reached puberty and that the maximum activity coincided with the period of estrus. These findings were confirmed by Slonaker (1924) who also demonstrated that the activity of the normal female rat tended to become increasingly irregular and less in amount during and following upon the period of life which might be considered as analogous to the menopause.

We again have no data which would serve to indicate whether or not a similar relationship between ovarian activity and general bodily activity exists in the case of the woman. Simple observation will, of course, permit us to state that the onset of puberty, the menopause and the occurrence of castration in women are certainly not associated with the same degree of variation in general activity as occurs in the rat.

There is no evidence in the lower animals or in women that castration is associated with any interference in the function of learning.

On first consideration it might appear that we should have more information concerning the effects of castration in women than in regard to the effects of this procedure in men since the ovaries are still removed with considerable freedom by the gynecologist. Closer inspection of the data shows, however, that there is a much greater probability of the testicles being removed or injured in accidents occurring in the prepuberal period than is the case with the ovaries. Furthermore, a certain amount of our information concerning the effects of castration in men has been derived from studies of individuals on whom this procedure has been carried out as part of a religious rite or social usage. The location of the ovaries has protected them from this fate. On the other hand, that location is one of the chief causes of their removal particularly in the postpuberal period. In the abdomen they tend to share the vicissitudes of the other organs in that region and may be removed because of conditions which have involved the pelvic organs generally or because of the effect which they exert on uterine bleeding.

It is most important to differentiate between removal of the ovaries before puberty has occurred and removal of these organs in women in whom the adult sex pattern has become well established.

The data which are available of necessity depend entirely upon the report of the individual subject. The general consensus of opinion appears to be that there is comparatively little interference with sex desire and receptivity in the case of castrated women who, before the procedure was carried out, had already developed well marked sexual behavior (Frank, 1929). There are no reliable facts as yet available concerning the effects of prepuberal castration in women.

It is generally agreed however that the effects, apart from those upon actual sex activity, are the more severe the earlier they are carried out. These effects, as is well known from clinical experience, consist in emotional instability, depressive and agitated reactions together with a number of lower level concomitants, notably sensations of flushing, sweating of the extremities, easy fatigability and cessation of menstruation. It is to be emphasized that these effects are experienced in varying degree by different women and that indeed in a small minority they may not, with the exception of the cessation of the menses, appear at all.

Effects of Substitution. As in the case of the male sex hormone, the earlier work was concerned with the effects of grafts and transplantation of glands. Later with the isolation of female sex hormones the emphasis has come to be placed almost exclusively upon the utilization of those preparations.

Considerable difficulty was experienced in performing successful grafting operations though Wang, Richter and Guttmacher (1925) report that they were able to restore the activity of castrated female rats to normal levels by the transplantation of ovaries.

In considering the effects of the female sex hormones upon behavior it seems desirable to confine ourselves to the action of the estrogenic hormone. Other sex hormones are produced by the organism, *e.g.*, the gonadotrophic pituitary hormone, but there is little available evidence that any save the estrogenic hormone has a definite action upon behavior.

In the lower animals estrogenic hormone has permitted resumption of sexual activity in castrated females (Allen and Doisey, 1924; Frank, 1929). In the case of castrated women Werner and Collier (1933) claim to have overcome the subjective symptoms associated with ovarian deficiency. In four out of their group of five there was in addition an increase in sex desire. Similar good results have been obtained in persons suffering from the menopausal syndrome (Sevringhaus, 1935). Attempts to demonstrate the psychological effects of estrogenic hormone therapy in the menopause have not been successful (Seward and Seward, 1937). These workers employed tests for steadiness, motor skill and associative activity, using as controls periods during which the patients received injections of saline. No significant differences were noted between the periods when estrogenic hormone and when saline were being given.

Numerous workers have investigated the action of estrogenic hormone with reference to the states of agitated depression which may occur during the involutional period in women (Bowman and Bender, 1932; Werner *et al.*, 1936). Some of the earlier reports were exceedingly enthusiastic; it now seems probable that the hormone acts mainly to set aside those symptoms which it does in the simple non-psychotic syndrome. In a certain number of cases the depression is also alleviated, but this is by no means the general rule. Little and Cameron (1937) have investigated the effects of the hormone upon anxiety occurring at the menopause and anxiety states occurring apart from the menopause. They found that where anxiety was accompanied by marked lower level involvement and where it did not arise from conflict the hormone acted to reduce the severity of the symptoms. Where the anxiety appeared to arise from conflict situations, particularly those centering around sex difficulties, the hormone was either without effect or actually appeared to intensify the anxiety which was experienced.

As in the case of the male sex hormone, considerable clinical work has been carried out in an attempt to demonstrate whether or not deviations in female sex gland activity can be associated with any of the major behavioral disorders. It can be shown, using the distribution of hair, the regularity of the menstrual cycle and the general physique as indicators, that abnormalities in sex development and activity are more commonly found in persons liable to mental breakdown than in normal individuals (Gibbs, 1924; *see* also consideration of Mott's work in section on Structural Functions), but as yet there is no definite evidence that any specific form of ovarian deficiency can be associated with any of the major abnormal reaction types. Further work awaits the development of the methods of sex hormone assay which are already being investigated.

Pancreas. The influence of the secretion of this endocrine upon behavior has been considered in the section dealing with carbohydrate metabolism.

Parathyroid Glands. Very little work has been carried out upon the relationship which exists between the activity of these glands and behavior. In view of the serious effects at the lower functional levels produced by the removal of these glands in animals and in view of their relationship to tetany in the human subject, it seems probable that more precise investigation will demonstrate that these glands exert an influence upon day to day behavior.

Pituitary. Investigations into the effects of the activity of this endocrine gland upon behavior suffer from the primary handicap that no agreement has yet been obtained with reference to the types or even the number of hormonal secretions produced by this gland. Moreover, the fact that this glandular structure appears to act as a regulator or controlling center for the rest of the endocrine system — particularly the adrenals, gonads and thyroid — renders it extremely difficult to determine whether effects obtained following removal or disease of any portion of the pituitary are to be considered as due directly to interference with the secretion of that particular area or to the effects produced by one or more of the rest of the endocrine system now released from control. Finally Lurie (1938) points out that at least in the case of the human subject, in attempting to correlate behavioral change with changes in endocrine function, we have to consider not only the direct effects of an interference with endocrine function but also the individual's reaction to these effects. This is well illustrated by the fact that the development of hypertrichosis in women in consequence of endocrine disturbance is a matter which is *per se* of little importance, but the reaction of the woman who suffers from this condition may be very serious indeed.

Total removal of the hypophysis in rats (Richter and Wislocki, 1930; Richter and Eckert, 1938) resulted in a reduction in total activity which amounted in a group of seven rats to a drop of 88 per cent in the preoperative activity. This reduction does not occur as long as even a small portion of the anterior lobe is left intact. In view of the interrelationship of the pituitary gland with the other members of the endocrine group, it is of interest to note that Atwell (1932) was able partially to restore the activity level of hypophysectomized rats by administering extracts of the suprarenal cortex.

Apart from these limited observations few data concerning the relationship of the pituitary gland to human activity have been obtained by means of animal behavioral experiments. Hoskins, in discussing Lurie's report (1938), refers to a dog which from being cringing and cowardly became, following upon removal of the hypophysis, alert and aggressive. His behavior was stated to have been brought back to its former level by means of the administration of pituitary extracts. Richter and Eckert (1938) refer to observations that their rats following upon hypophysectomy showed considerably more nest building activity than previously. Finally, it seems possible from the preliminary scattered reports that the administration of the lactogenic portion of the pituitary secretion may result in an increase in maternal activity.

In the human subject our knowledge concerning the relationship of the pituitary gland to behavior remains on a basis which is almost entirely clinical. Lurie (1938) refers to children suffering from hypopituitary disturbances of the Froelich type as showing a prolonged reaction time. He claims that this fact may give rise to an erroneous impression that the child is actually mentally retarded whereas, if sufficient time is given, he may be quite capable of giving a good account of himself on the usual intelligence tests. Levy (1936), in reporting the high incidence of submissiveness of children suffering from Froelich's syndrome, also notes that these children though slow, shy and timid have good intelligence levels.

In addition to the submissive reaction occurring in Froelich's syndrome in children Lurie (1938) describes the Lorain-Levy type of pituitary disorder as being associated with a dominating, aggressive and alert attitude. Numerous clinical observers have recorded that the acromegalic type of pituitary disturbance is accompanied in its early stages by irritability, restlessness and some increased sexual excitement. Later, however, dullness, inactivity and impotence become the final characteristics.

It must be emphasized, however, that the experimental work which has been done upon these syndromes is limited in the extreme, and further light upon the interrelations between pituitary activity and behavior must await further technical advances both in the field of endocrine assay and in the field of quantitative estimation of higher level functions.

Vitamin Function

The activity of the vitamins in relation to variations in behavior has been studied over a considerably shorter period than has that of the endocrine glands. The field is by no means completely explored, but it seems reasonable to make the following general statement with reference to the contrasting relationships of the hormones and the vitamins to behavior — the influence of the hormones appears to be considerably more specific than does that of the vitamins. For example, no vitamin exerts such a clear-cut action as do the sex hormones. While B_1 seems to have a rather direct action on the process of learning, the results of deficiency in most other vitamins, *e.g.*, D, seem to produce behavioral changes which are barely distinguishable from those associated with any other serious disturbance of lower level functioning. Whether this difference in specificity can be related to the fact that the hormones are developed within the individual while the vitamins are obtained from a varied diet is a matter for consideration. Of the various vitamins at present known only certain components of Vitamin B complex and Vitamin C are known to exert any influence upon human behavior. These will be discussed in detail. Vitamin A deficiency may be accompanied by night blindness. Vitamin D deficiency produces rickets, but there is no evidence that it is associated with behavioral changes save those secondary to the pain and weakness which accompany this disease. Vitamin E deficiency is associated with sterility in animals, possibly in the human subject; and Vitamin K is concerned in the clotting of blood.

Vitamin B_1. This component of the B complex is of considerable importance since it appears to be necessary for metabolism of nervous tissue. In animals fed on B_1 deficient diets a polyneuritis develops, as well as certain behavioral changes. These latter have been investigated in various respects. Maurer and Tsai (1929, 1930) have shown that rats deprived of Vitamin B_1 from birth were considerably slower in learning to run mazes than were a control group. The normal rats were about twice as efficient as the rats brought up on Vitamin B_1 deficient diets. This was confirmed by Bernhardt (1934), and it was shown by Bernhardt and Herbert (1937) that the effects of this deficiency were the more deleterious with respect to the capacity to learn the earlier in the life of the animal the deficiency occurred. Poe, Poe and Muenziger (1939) showed that, in addition to interference with learning, Vitamin B_1 deficiency also produced a deterioration in retention in rats. This is of considerable interest in connection with the possible part played by Vitamin B_1 deficiency in persons suffering from alcoholic Korsakow reactions. The fact that Fitzhugh (1939) found that the irritability present in rats which had been addicted to morphia was reduced when Vitamin B_1 was added in excess to the diet is of interest in connection with morphia addiction in the human subject.

With respect to the human subject experimental data are of necessity more limited. Colby *et al.* (1937) have been able to show that infants fed upon a diet to which excess of Vitamin B_1 was added showed, up to the sixth month of life, increased speed in developing basic behavioral patterns, increase in alertness and perception as well as some increase in the speed of learning. By the ninth month the difference between the control infants and those to whom excess B_1 had been given was less marked and at the twelfth month the latter group were distinguishable from the control group only in that they were rather less adept in standing alone than were those children who had been brought up on an ordinary diet. Jolliffe *et al.* (1939) have given Vitamin B_1 deficient diets to normal subjects and have noted that as early as the fourth day symptoms appeared in 4 out of the group of 5. These symptoms were fatigue and lassitude as well as anoxia and precordial pain. Similar findings were reported in three normal subjects by Williams, Mason and Smith (1939). In view of the evidence which has been put forward on behalf of deficient oxidation in schizophrenia (*see* section on Oxidative Function) and in view of the fact that B_1 is known to be an oxygen catalyst, it is of interest to note that intensive oral, intravenous and intrathecal administration of Vitamin B_1 produced no clinical improvement in a group of schizophrenic patients and caused only random changes in the Stanford-Binet scores (Chase, 1939).

There have been numerous reports of the value of Vitamin B_1 in the treatment of alcoholic Korsakow reactions. This is of theoretic as well as practical interest in view of the reports to the effect that Vitamin B_1 deficiency results not only in impairment of learning in rats but also in reduction in the capacity to retain (*see* above). Unfortunately few of the investigations appear to have been well controlled. Partial control was, however, achieved by Bowman, Goodheart and Jolliffe (1939) who report that they have studied a group of 51 patients suffering from Korsakow psychoses, all of whom were treated by means of a diet high in Vitamin B_1 but 20 were given 10 to 50 mg. thiamin chloride parenterally in addition. The latter group showed a recovery rate which was approximately seven times that of the remainder of the group.

Vitamin B_2. This vitamin was originally described as the pellagra preventing factor. It is now known to be in actuality a complex. In this complex there have been distinguished nicotinic acid, riboflavin and B_6. It is probable that it contains other as yet unknown factors.

Nicotinic acid deficiency produces pellagra. The behavioral picture which attends this condition is rather varied. Subclinical pellagra is accompanied by numerous rather vaguely stated complaints — fatigue, anorexia, restlessness, apprehension and palpitation. The more severe forms of pellagra are frequently accompanied by well marked abnormalities of behavior. Delirium is often present, the patients being disoriented, restless and showing both loss of recent memory and a tendency to confabulate. States of depression and paranoid reactions have also been noted. These abnormalities of behavior have not yet been subjected to precise psychological investigation. Spies *et al.* (1938), in well controlled studies, have shown that nicotinic acid is a specific therapeutic agent in respect to these behavioral abnormalities. They demonstrated that improvement regularly appeared within 10 hours to 6 days after the administration of nicotinic acid has commenced; they also showed that if the patient failed to continue his treatment after discharge relapses frequently occurred; finally, they recorded that patients suffering from severe pellagra developed psychotic reactions in hospital if they were not put upon a diet containing nicotinic acid. When this diet was added these psychotic reactions subsided. Reports have also been made to the effect that nicotinic acid exerts a favorable response upon certain of the behavioral reactions associated with alcoholism and also upon some of the confusional states found in the senium. There is as yet no adequate confirmation of the findings.

The remaining known portions of the B_2 complex, namely riboflavin and B_6, have not so far been identified with any aspects of human behavior. Some attempts have been made to investigate the effects upon behavior of the total B complex and even of a combination of a large series of vitamins. The value of this procedure is quite dubious. The only argument which can, with any degree of validity, be urged on its behalf is that when these vitamins are used in excess simultaneously a synergistic action may take place which is absent when they are used alone. Balken and Maurer (1934) found that the performance on psychological tests of children fed an excess of Vitamin B complex was significantly better than that of a control group. Balken, Maurer and Falstein (1936) fed increased amounts of Vitamins A, D, B_1 and B_2 and iron to a group of 46 deteriorated male schizophrenic patients over a period of a year. They used as controls a similar group of patients who were fed on the ordinary hospital diet. Both groups were free of any physical defects and showed no evidence of undernourishment. They were tested before and after the experimental period by the Grace Arthur Point Performance test on retention. There was a considerably better performance by the group on the reinforced diet than by the group on the ordinary diet. No evidence of actual recovery is cited, and it is impossible to state how far the general tonic effect of heavy B_1 administration may have been a factor in increasing interest and effort and thereby raising the score.

Vitamin C (*Cevitamic Acid*, *Ascorbic Acid*). Deficiency in this vitamin is associated with scurvy. This condition may be accompanied, especially during its more severe phases, by apathy, lassitude and at times delirium. The effects of non-pathological Vitamin C deficiency in children have been studied by Colby *et al.* (1937). Six normal infants were left for three to four months on a diet containing just sufficient Vitamin C to prevent the appearance of fresh symptoms of scurvy. Compared with a control group these children showed greater emotional instability with greater difficulty in adjusting themselves to the experimental situations. Their behavior was more stereotyped and they scored lower on the Gesell and Bühler-Hetzer normative tests. Lemmel (1938) carried out a similar investigation on 110 children in a home for the deaf and dumb. All the children were put on a basic diet which was deficient in Vitamin C, but half of them were given in addition 100 mg. Vitamin C daily. It was found that those children who were not given extra Vitamin C became dull and wanting in initiative. They were observed to lack cheerfulness and to be incapable of mastering school work which had previously been within their capacity. Wortis (1939) has reported that guinea pigs kept upon a diet low in Vitamin C become apprehensive and are easily upset by slight sounds.

Apart from scurvy, the Vitamin C level of the blood and cerebrospinal fluid has been found to be low in several conditions some of which are associated with behavioral abnormalities and some not. Wortis, Wortis and Marsh (1938) have shown that a low Vitamin C content of the blood and cerebrospinal fluid is present in those alcoholic patients in whom there is neural and behavioral change. The levels are normal where these changes are minimal or are entirely absent. Correction of this condition does not improve the behavioral abnormality.

It has also been shown that the Vitamin C levels in the aged are low (Plaut and Bülow, 1937; Monouni, 1937). This has been investigated in a group of patients suffering from the psychoses of the senium (Remp *et al.*, 1940). The levels were found to be low in both blood and cerebrospinal fluid. They remained low even though the hospital diet contained amounts of Vitamin C adequate to keep the levels of young adults at the usual points. The addition of 300 mg. Vitamin C to the daily diet raised the levels but exerted no effect upon the behavior. It seems probable that in the aged psychotic patients there is difficulty in assimilating Vitamin C from the gastro-intestinal tract.

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CHAPTER XXI

STRUCTURAL FUNCTIONS

THE earlier thinking in the psychiatric field made a definite separation between structure and function. This concept has only a limited fruitfulness and has been largely abandoned by the social sciences though it still dominates much of day to day medical thinking. Numerous efforts have been made to provide a series of concepts to substitute for those which arise from the above mentioned hypothesis. These efforts are best developed in the behavioristic, gestalt, psychobiologic and psychosomatic postulates.

From the point of view of experimental psychiatry it is a matter of practical experience that it is fruitful at one time to work with the organism as a whole and at others with functional subdivisions. The older concept of structure is no longer adapted to our present day thinking and procedures.

What was formerly considered structure is now thought of in terms of functions which are peculiarly fundamental to the existence of the individual and which for this reason show a very slow rate of adaptation. It is clear that the general shape of the organism has an influence upon behavior. The loss of an extremity or serious functional change, such as may result from vertebral disease, profoundly affects the activities into which the organism may enter and thus constitutes limitations for which compensations and readjustments must be made at the behavioral level. It is also clear that removal of or damage to various parts of the organism gives rise to functional disorders which may entail behavioral change.

Body Image. The concept which the individual has of the shape and location of his own body has been investigated (Schilder, 1935). This field of enquiry is derived in part from the assertion that the infant is not at first able to differentiate between his environment and the various portions of his own body. This rests upon observation only and cannot yet be accounted as well established. The major impetus to study the body image has been derived from reports of individuals who have suffered brain damage and who have lost the ability to feel that various parts of their body are their own. Analogous to this is the experience of those individuals who have suffered an amputation and who for varying periods thereafter perceive such sensation as they would if the amputated limb were still attached to the rest of the body. A similar condition may arise in hysteria. This is not to be confused with simple hysterical anesthesia. The relationship of these phenomena to depersonalization has not yet been clarified.

The relationship of disturbance of the body image to somatic delusions has been investigated by Angyl (1936) who showed in a small group of patients that somatic delusions may be associated with a considerable loss of capacity to maintain a body image. He reported in an earlier study that such delusions as that the walls were pulsating under the patient's hand or that the floor was soft and heaving occurred in association with a disturbance of the body image and could be thought of in terms of a loss of the capacity to differentiate between the body and the environment.

From the neurological side there is some evidence that lesions of the dominant hemisphere tend to produce alterations in the patient's concept of both sides of his body, while lesions in the other hemisphere interfere only with the concept of the contralateral side. The lesions tend to be in the parietal or in the parietal-thalamic region.

Body Shape. That there is an association between the appearance of an individual and his behavior has been long surmised. It is clear that a great number of the alleged associations are very superficial and indeed frequently exist conventionally rather than in reality. To take a very trite example, we are familiar with the fact that although the popular mind demands that the different characters played upon the stage — the villain, the hero, the heroine, the leader and the reformer — should be represented by persons having certain characteristics of appearance, in actual fact the persons who play the parts, even should they conform explicitly in their external appearance to the popular conception, may possess character traits which are very different from those that they portray upon the stage.

Attempts have been made for centuries to associate the appearance of individuals with a proneness to certain diseases. This "soil" theory of disease has found its counterpart in the "seed" theory which emphasizes the external stimulus as the factor in disease production. When the one theory is in dominance the other is necessarily in partial eclipse. While the successes encountered in the field of bacteriology advanced the fortunes of the seed theory, the more recent work upon the endocrines and the bearing which the activity of the various endocrine glands have upon behavior has tended to restore the soil theory to its former prestige. While, too, the earlier work was largely upon an observational and even apparently upon an intuitive basis, the advance of statistical analysis into the field of human behavior has enabled us to strip, at least to some extent, fancy from fact.

Since the beginning of this century there has been a considerable brightening of interest in the soil theory, particularly in regard to mental disorder. This interest at its inception took the form of an attempt to delineate prepsychotic personality types. Considerations concerning the part played by a "shut-in" personality in its development of schizophrenia appeared frequently in the literature of the first two decades of this century. More precise methods of study have quite failed to accord validity to this concept. Similarly, our failure to devise methods adequate to measure interpersonal relations has resulted in considerable confusion concerning the part played by the so-called introverted and extroverted personality types as predisposing factors in certain forms of abnormal behavioral reaction.

This concept of a specific prepsychotic personality type did, however, find a fair degree of support at the time of its inception and there was a natural attempt to extend the theory to the extent of postulating a specific or relatively specific prepsychotic body type.

Attempts to delineate body types and to associate them with behavioral patterns have been made almost since the beginning of medicine. Almost all these classifications, while differing in detail, used as their fundamental points of differentiation the size of the body cavities, the length of the extremities and the relation of these two sets of measures to each other. In the psychiatric field the work of Kretschmer (1925) has been most influential. This worker differentiated three main bodily types — the pyknic, the athletic and the asthenic; in addition he recognized a further less well-defined group, the dysplastic. He considered that these groups showed a fair degree of correlation with certain of the reaction types. The pyknic type was found, he stated, with special frequency among the manic depressive group; while the asthenic, athletic and dysplastic types were more frequently found to be associated with the schizophrenic reactions.

These types were delineated partly by means of measurement and partly impressionistically. Indeed, in following Kretschmer's work we at times have the feeling that he tends to place more weight upon impression than upon measurement. His types are described in considerable detail and with vivid imagery. The following is a description of the general characteristics of the types:

The pyknic type has as its outstanding characteristic the marked development of the trunk and head. The face is rounded and the contours soft, the neck is short and massive, the abdomen is full, and in later life there is often a tendency toward corpulence. The chest is deep rather than broad. The extremities are more slender, the outline of the muscles being obscured by the prevalent fatty covering. Though in youth the limbs may be slender and delicately rounded, in later life there is a tendency toward increased fatty deposit here also.

The athletic is characterized by the good development of the skeleton and of the musculature; the head is long and the neck is free and the trapezius muscles are particularly well developed. The shoulders are broad and very well developed; the trunk slopes down from them to the rather narrow hips. The limbs are strong and muscular. The muscular outlines of the body are particularly prominent in view of the fact that the fatty covering is not very well developed.

The asthenic type is characterized by slightness, the subjects being of normal height, but being rather slenderly built. The face contour is described as being that of a shortened egg. The shoulders are narrow and the extremities are lean and delicately formed. The chest is long and narrow and flat. The skin is thin and there is little deposit of fat. There is little body hair. The abdomen is also thin.

The dysplastic types contain individuals showing numerous variations from the above described types. Among these variations Kretschmer describes eunuchoid forms with loss of some of the distinguishing sex signs, such as the characteristic pelvis form, or sex hair distribution. He also describes infantile and hypoplastic forms.

Since Kretschmer's original delineation a great deal of work has been carried out in attempts to evaluate his concepts. The more critical studies have made use of statistical analysis and have sought for indices to take the place of the more impressionistic approach. Both Wertheimer and Hesketh (1926) and Adler and Mohr (1928), who have followed more precise procedures in studying this problem, consider that pure types such as those described by Kretschmer do not exist. They believe that the types are best conceived as widely separated points upon a curve of normal distribution. Later workers have been still more critical and at present no consensus of opinion exists even upon the question of the correlation of the original types with specific abnormal behavioral patterns (Burchard, 1936). It is agreed that the body types, if they do exist, are simply, as the first critical statistical investigations showed, extremes on a curve of normal distribution.

Attempts have also been made to correlate body types with normal behavioral patterns or with certain personality traits such as reaction time, perseveration, intelligence, ability to attend to several matters simultaneously. The attempts to correlate body type with behavioral pattern are naturally limited to a serious degree by the fact that we do not possess any adequate means to measure such patterns. This is also true in large measure of the attempts to find correlations with personality traits (Kraines, 1938; Pillsbury, 1939).

Nevertheless, in spite of the confused and conflicting data which have been obtained from this field of study one must bear in mind that common experience over centuries has tended to ascribe certain behavioral characteristics to individuals possessing certain physical characteristics. The reasons for this do not seem to have been touched upon by the investigations which have been made so far. A new approach might be made by means of a postulate that it is the reaction of society to certain physical characteristics which tends to determine the behavioral patterns developed by persons who possess these physical characteristics. This possibility has been explored with some degree of confirmation by Cabot (1938).

Structural Defects. The work in this field has broadened very considerably in the last few decades. This is in large part due to the fact that the experimental method has been introduced. Progress in this field was for long retarded due to the widely held belief that behavior in man was qualitatively different from that which was to be found in the lower animals. So long as the mind-body concept was maintained opinion was almost unanimous in declaring that the outstanding differentiation between man and the lower animals was that the latter were incapable of "reason." Consequently, animals were little employed as a means of acquiring information concerning behavior. It is now recognized, of course, that many of the fundamental behavioral patterns can be traced down through a long series of species just as is the case in regard to the fundamental principles of circulation or the healing of wounds. Indeed opinion has now swung so far in the other direction that it is necessary to emphasize that what is learned of behavior through the experimental production of defects in the central nervous system of animals may not be susceptible of transfer without reinterpretation into the field of human behavior. Alongside this new experimental approach there exist studies in human behavior based upon the effects of accidental or pathologically produced defects. This must be so in the case of the human subject. It is proposed to consider this field first in terms of the data derived from experimental lesions and second in terms of studies on the results of accidental or pathological lesions.

Experimentally Produced Defects. The earlier work in this field which indicated localization of motor and sensory areas gave rise to an expectation that localization of the higher functional activities might also be possible. Since that time more extensive work has shown that there is in fact remarkably little localization of function in the cortex and indeed it seems probable that many complex activities can be carried out by the subcortex (Jacobsen, 1939). Nevertheless, it is possible to state that certain areas of the brain are specially involved in certain reaction patterns.

There is evidence, already considered in the section on emotion, that the hypothalamus is concerned in the coordination of the lower level manifestations of the emotional reaction (Bard, 1934). It is to be noted, however, that this area should in no way be considered the "center" of the emotional reaction. Indeed, since the experimental work has, of necessity, been carried out exclusively in animals, there is no indication that excitation of the hypothalamus produces the feeling tone appropriate to the lower level activity which results (Lashley, 1938). As yet there is no evidence that the hypothalamic area is involved in any of the abnormal emotional or mood reactions. This question is still being explored and in particular enquiry has been directed to the possibility that the inadequate emotional responses of the schizophrenic and his generally inadequate sympathetic reactivity may be correlated with a primary abnormal functioning of the hypothalamic area.

The most extensive work in the field of experimental interference with brain activity has been carried out with reference to the cortex. Complete removal of the cortex in cats results in considerable stereotypy of behavior. Moreover, there is little tendency for the animal to show any combinations of the various behavioral responses (Rioch, 1938). While it is clear that the primary projection areas are mainly concerned with relatively specific functions, the previous statements regarding localization of specific activities in certain areas are no longer valid. It has been shown largely through the work of Lashley (1929, 1933) that the total amount of cortex destroyed is of major importance, at least in rats, with reference to the ability to carry out higher level activities. In the higher animals the situation is less clear. While it seems probable that the total amount of cortex which is destroyed exerts an influence upon the performance of higher level activities, quite apart from the location of the destruction, there is good evidence that some degree of localization of function exists. Moreover, in the primates and particularly in man unilateral lesions, at least in the prefrontal region, even where extensive, produce much less disturbance than do bilateral lesions. Jacobsen (1935) and Jacobsen, Wolfe and Jackson (1935) have reported that, while unilateral lesions in the prefrontal region in monkeys and chimpanzees produced no deterioration in the capacity to carry out a series of behavioral tests, bilateral lesions in the same region produced quite definite changes. These consisted in serious impairment of recent memory. The animals were unable to recall under which of two cups food had been hidden. This loss was in some instances so severe that the animal was unable to recall correctly after intervals which were as short as two seconds. Lesions in other parts of the cortex did not produce this effect which, moreover, could not be reversed by extensive reeducation. It must, however, be noted that this constituted a highly specialized type of recent memory loss since there was no inability to learn new tasks based upon visual discrimination or to learn how to obtain food from a box by means of manipulating levers. It was pointed out that in the case of the latter tasks the cues for correct performance are undoubtedly present at the time of test while in the case where the animal has to choose between two cups he has nothing to depend upon save his memory of having seen food put under one of them. The findings are clearly of great theoretical interest in connection with the type of memory defect found in the Korsakow psychosis and in organic brain syndromes in general.

Some evidence that activity in monkeys is controlled through the prefrontal cortex has been reported by Richter and Hines (1938). These authors have shown that destruction of this area resulted in a permanent increase in activity. There is considerable doubt whether these findings can be applied directly to the human subject since numerous clinical reports exist which described dullness and apathy as the most usual consequence of damage in this area. Extirpation of both temporal lobes in the rhesus monkey results in a loss of the ability to recognize the nature of objects by means of vision alone. Animals which were hungry would select edible and nonedible objects indiscriminately. Those which were not suitable for food would be dropped after having been taken into the mouth but would be picked up again a few moments later if the animal had to depend on its vision alone for selection. There was also a very considerable diminution in emotional reaction, the animals meeting with indifference situations which would ordinarily evoke anger or fear.

Information concerning the relationship of brain structure in man to behavior has been obtained in part from the study of the results of removal of brain tissue at operation and in part from the study of individuals who have suffered from vascular and other cerebral accidents.

The amount of material which is available from the investigation of the effects of operative removal of brain tissue is limited. This is due in the first instance to a fact recorded above, namely, that destruction, even though extensive, frequently fails to produce discernible changes in behavior in man and in some of the higher monkeys so long as it is confined to one lobe. A further reason for the limited amount of information derived from this source is the fact that methods permitting refined evaluation of behavior are still in a rudimentary stage of development.

Removal of the greater part of the right cerebral hemisphere (Dandy, 1928; Rowe, 1937) was followed according to the first worker by little or no change. Rowe reports that it was possible to demonstrate some impairment of recent memory, emotional instability and release from former inhibitions in the one case which he studied. Penfield and Evans (1934) have reported careful evaluation of the behavior of patients on whom various lobectomies had been performed. In one patient, in whom the left temporal lobe had been removed, there ensued some difficulty in localizing sound in the side opposite the extirpation and also a difficulty in assessing comparative distances. Removal of either right or left occipital lobe is accompanied by no change in capacity or behavior, though, of course, interference with vision occurs.

Removal of either frontal lobe was followed by changes which could not be readily evaluated by any of the available test instruments. It was apparent, however, from long term observation that a certain loss of initiative had occurred and that at least in one case difficulty in planning and in carrying on highly abstract activities (*see* later consideration of Goldstein's work) had supervened. It has been suggested that intelligence is not seriously impaired unless the dominant hemisphere is extirpated (German and Fox, 1934). Attempts have been made to localize this area more precisely and Alford (1937) has suggested the central portion of the dominant hemisphere as being of particular importance. There is, however, little general agreement in this field.

Lidz (1939) examined a patient in whom the right frontal lobe had been removed back to a line running through Brodman's area 6. Preoperative intelligence, memory and personality tests were available. These naturally fell with the period of the patient's illness (right prefrontal oligodendroglioma) but were supplemented by means of extensive questioning of his friends regarding his former capacities. Immediately subsequent to the operation there was some dullness and also some tendency to obsessive thinking (*see* discussion on leucotomy). Within a month after operation, however, repetition of the various tests demonstrated no diminution in scores as contrasted with those obtained prior to operation. Hebb (1939) has investigated the intelligence scores in the case of four patients in whom there had been extensive removal of the left frontal lobe. The intelligence levels were above normal.

Considerable caution, however, must be observed in attempting to establish precise localization on the basis of these investigations. We may note, for example, that certain authors have suggested that "memory traces" must be stored in the posterior part of the brain since removal of the frontal lobes, while resulting in some impoverishment of recent memory, does not destroy the capacity to reproduce older material. Nevertheless, each lobe has been removed in various patients without any serious memory defect being occasioned. It is still necessary to mention at least provisionally the concept of mass action even in the higher animals.

Bilateral lobectomies are exceedingly rare. A detailed study of one such case has, however, been reported. Brickner (1934, 1939) has investigated over a number of years the behavior of a patient in whom both frontal lobes anterior to the motor areas were removed. The area of removal extended back to Broca's region on the left. The fundamental change in this patient was his reduced capacity to synthesize his experiences. Arising from this were difficulties in retention of recent impressions, and stereotypy in thinking. There was, in addition, difficulty in evaluating situations and an impoverishment of the power to carry on highly abstract thinking. Moreover, it was noted that the patient was less inhibited by the usual social restraints. He had become irritable and boastful and showed a degree of petty aggressiveness toward his family which had not been present before his operation. Review of this patient's behavior five years later recorded the fact that it had undergone very little change. It is of special interest that the maturing process which is continually at work in the normal individual was absent. In consequence his attitudes, his habits and his way of thinking about things had undergone strikingly little change.

Some further light upon the relation of brain structure to behavior has been yielded by the leucotomy operative procedure introduced by Moniz (1936, 1937). This operation consists in severing some of the tracts connecting the prefrontal area with the rest of the brain. This is achieved by introducing a leucotome through trephine openings in the anterolateral aspect of the skull, and cutting several cores in the subcortical white matter on either side.

It is of interest to note that while cutting the fibers on one side produces little or no effect, the severance of fibers on the second side causes an immediate cessation of anxiety. Dullness and stupor may temporarily supervene and in certain cases disorientation is noted. These symptoms usually subside within a month. The patients usually show, however, a varying degree of loss of initiative and inability to synthesize experience. In many instances this can be brought out only on detailed investigation, and the degree of defect is often so slight as in no way to interfere with the patient's ability to carry on his former activity (Watts and Freeman, 1938). On the basis of a study of 48 patients, on whom this procedure was carried out, these workers (Freeman and Watts, 1939) have endeavored to evaluate certain of the functions of the frontal lobe. Inability to synthesize data, loss of appreciation of the social significance of a setting, and inability to foresee accurately what the consequences of a given line of action will be are the outstanding characteristics of extensive frontal lobe damage and are found, though to a minimal extent, following upon leucotomy. From this they conclude that the chief function of the frontal lobes is the synthesizing of data and the planning of action. This latter involves the creation by the patient of tentative images of events and his participation in them.

The work in this field is still in its early stages and full agreement as to the fundamental relationship between brain structure and behavior cannot yet be obtained. Goldstein (1936[a, b]) considers that the fundamental functional deficit which follows upon damage in the frontal region is not a loss of the capacity to form syntheses, as is suggested by Brickner (1934, 1939), but rather a diminution in the capacity to deal with abstractions. By means of simple performance tests he has been able to show that the individual in whom part of the frontal lobe has been destroyed is capable of carrying out the tests quite adequately so long as all the factors are before him in concrete form. However, if he is asked to reconstruct a design in such a way that he has to elaborate new concepts failure frequently occurs. This inability to deal with abstractions may cause disturbances in many fields of behavior. Goldstein records, for example, the fact that while one of his patients was quite able to point to the direction from which a noise came he was not able to describe the direction in which the origin of the noise lay. Similarly, he reports the case of a woman who knew perfectly well the way from her ward to two locations in the hospital, but on being asked to go directly from one of the two locations to the other she was quite unable to conceptualize the spatial relationship of the one to the other.

Goldstein lays considerable emphasis on the viewpoint that the brain acts in many respects as a whole and therefore the concept of localization assumes a subsidiary part in his concepts. In addition to the inability to deal with abstractions, which has just been described, this worker reports the following main disturbances as consequent upon brain damage: (1) a reduction of receptivity which increases in proportion to the size of the lesion. This results in the typical slowing of the individual who has suffered brain damage. (2) A prolongation of the reaction to stimulus which may result in the increase in perseveration noted in persons suffering from organic brain disease. (3) An increase in the importance of external stimuli. This gives rise to the frequently recorded symptom of distractibility. (4) An inability clearly to differentiate between an object and its setting. Harrower (1939) has investigated certain aspects of concept formation in a group of 30 patients who suffered from cerebral lesions and a group of 30 normal controls. He made use of an adaptation of the ambiguous figure and found that there was a considerable degree of perseveration in his patients who tended to maintain their original concept even though the alternative concepts of the ambiguous figures were demonstrated in detail.

Cerebral Pathology. Very little information of a reliable character has been obtained with regard to the relationship of brain structure to behavior from the study of cerebral pathology. In considerable measure this statement holds true even when the accident is in the form of a hemorrhage or tumor occurring in the so-called speech areas. Save in rare instances post-mortem study fails to give a clear picture of the exact scope of the damage which was present during life.

This material appears to fall so definitely into the category of observational rather than experimental data that only the general outlines of our information will be stated. Lesions in the frontal-parietal-temporal area of the dominant hemisphere usually, though not inevitably, produce interference with the use of language. The more anteriorly located lesions tend to produce mainly difficulties in the expression of thinking; lesions in the posterior part of this area tend to produce interference with the understanding of what is said, and with internal speech. A large number of clinical syndromes have been reported — alexia, agraphia, word deafness. These syndromes are only in the rarest instances present in pure form, and indeed there is reason to doubt many of the concepts upon which this classification is based. Closer investigation shows that even in those cases in which a particular type of interference with the use of language appears to be present in pure form there can usually be detected a generalized reduction in ability, showing itself frequently in slowing of reaction, a limitation of the capacity to learn or a reduction in the power to retain.

A searching criticism of the earlier work in this field was made by Head (1926) when he pointed out that many of the current concepts of aphasia were based upon the postulate that we think in terms of words whereas it is now clear that we think for the most part in terms of verbal and auditory images. Further, the work of Lashley (1929), to which reference has already been made in this section, demonstrates the necessity of bearing in mind the fact that in many of its activities the brain acts as a whole. This point of view renders much more understandable the fact that in addition to the specific defects which may follow upon a lesion in the frontal-parietal-temporal region there is also a general reduction in capacity.

Some work has been done upon the problem of restoration of function after damage to brain structure. It seems certain that, after the period of immediate reaction has subsided, practice and incentive may result in a varying degree of improvement in performance. This seems, however, to be much more due to a reorganization of the remaining resources of the brain tissue than to any true rehabilitation (Lashley, 1938). This worker also points out that, while specific activities may benefit to some extent from training, there is little improvement in certain basic defects such as diminution in the capacity to synthesize, slowing of the rate of learning, reduced capacity to deal with abstractions and loss of spontaneous activity.

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CHAPTER XXII

STRUCTURAL FUNCTIONS (*Continued*)

In the preceding chapter we confined ourselves to a consideration of the work which has been carried out upon the interference with structure in the living organism. This work is of relatively recent origin and behind it lies an extensive series of studies upon the correlation between behavior and abnormalities of structure which were found after death. This is clearly a more indirect and less reliable approach. There are serious technical difficulties such as the differentiation of post-morten from ante-mortem changes, and the distinguishing of the effects of intercurrent diseases from the structural changes which are suspected of correlation with the deviations of behavior. Furthermore, while, in the case of studies upon the living subject, it is possible to contrast the behavior shown before interference with that shown after interference, in the case of attempts to correlate post-mortem findings with behavior reliability has to be placed upon normal controls. The difficulties inherent in the selection of such controls are considerable. Finally, the fact that in this mode of approach we are entirely unable to limit the extent or location of the lesion renders it almost impossible to assemble an array of comparable observations. In consequence of these serious obstacles there has been a considerable falling off in the amount of work which has been carried out in this field. The earlier workers in the psychiatric field found a close acquaintance with brain anatomy and neuropathology necessary for the completion of their training and sought in this field an outlet for their research activities. With the development of interest in the organism in action this has changed, and biochemistry and physiology have become as necessary to the study of lower level functions as psychology, sociology and anthropology are in the investigation of the higher levels.

Nevertheless, post-mortem studies can afford opportunities for investigation which cannot yet be duplicated by experimental interference with the living subject. The data derived from these studies will now be considered. Included in this section are certain closely related or derivative studies carried out in the living subject. A survey of the field readily shows that by far the greater amount of this work has been carried out upon those structures which mediate the coordinating functions of the organism, namely, the central nervous system (one may remark upon the limited amount of work which has been done upon the effects of structural damage in the autonomic nervous system and its relation to behavior), the endocrine system and the cardio-vascular system.

Central Nervous System. Changes in the structure of the central nervous system have been long sought in connection with abnormalities of behavior. There is general agreement that such behavioral deviations may be associated with aging, with serious brain infections or degenerations or with neoplastic or developmental abnormalities.

Schizophrenia. The situation is much less clear in relation to such conditions as schizophrenia, though extensive work has been carried out on this problem from the time since the disorder was first delimited. Kraepelin (1913) stated that in his schizophrenic patients he found no striking macroscopic changes in the cranial contents save for occasional thickening and edema of the pia. He reported that the cells of the deeper layers of the cortex were shrunken and that the nuclei were often swollen. Lipoid decomposition products were present and a diffuse loss of cortical cells was noted. These changes were most severe in the second and third layers of the cortex. He also described a hyperplasia of the glia.

Numerous workers have confirmed these reports (Alzheimer, 1913; Josephy, 1923; and Fünfgeld, 1925). Both Josephy and Fünfgeld found that the dropping out of cells was most marked in the third and fifth layers of the cortex. Josephy states that while this dropping out process was most marked in the frontal and temporal regions it could be found in lesser degree throughout the brain. Fatty degeneration and sclerosis of ganglion cells were found to be widespread and were present not only in the basal ganglia and medulla oblongata but also in the spinal cord. He considers that these changes represent the terminal stage of a process and is inclined to consider that this process is intimately related with the appearance of the primary schizophrenic symptoms described by Bleuler. The latter, while describing (1930) the presence of somewhat similar changes in the brain of schizophrenic patients, states specifically that there is no evidence as to how these changes should be interpreted nor as to what effects they may produce upon the behavior of the individual.

The great difficulty in obtaining unequivocal material, both in the form of controls and representative schizophrenic cases, has been pointed out by Dunlap (1925). His own material was limited to uncomplicated schizophrenia occurring in young persons and his normal control material was drawn from persons who had died suddenly, usually in accidents. He found it was impossible to show that there was destruction of cells in the cortex of the schizophrenic patients. This was tested by the simple process of counting the cells, particularly in the layers said to be specially affected. The control and schizophrenic sections were mixed so that the investigator was unaware of the origin of the slide which he was examining. On separating the slides afterward and referring to the counts no essential difference could be found. Since any loss in cells would be followed by loss of their nerve fibers and since if this loss were extensive the weight of the brain would be affected, both the weight and the size of the brains from the schizophrenic and normal controls were investigated. No difference was found.

Later workers have tended to be more conservative in their evaluation of changes in the schizophrenic brain. Spielmeyer (1931) emphasizes that it is now known that cell-free areas of cortex may be found in normal individuals and that fatty degenerative changes may be found in the glial cells and vessel walls of young normal individuals as well as schizophrenic patients. He reports, nevertheless, that a pathological cellular loss may be found in the third layer of the cortex in clear-cut cases of schizophrenia and that there are at times very large accumulations of fat. He considers that these findings place schizophrenia in the category of organic diseases, but thinks that the findings are not sufficiently definite to permit their designation as the essential pathology of schizophrenia. Peters (1937), on the basis of examination of 14 selected schizophrenic brains and 8 normal controls, reports that dropping out of cells occurred in both groups and that it was impossible to distinguish the groups on the basis of the location or the extent of the dropping out. Similarly, it could not be demonstrated that the changes observed in the cells, including fatty degeneration, were more in evidence in the schizophrenic than in the normal control group.

Buscaino (1921) has reported that grape-like areas of lipoid degeneration could be demonstrated in the schizophrenic brain. He stated further that the location of these areas varied with the type of schizophrenia. They were found particularly prominently in the globus pallidus in the catatonic group and in the thalamus in the hebephrenic reaction. Freeman (1925) examined 100 consecutive brains of psychotic patients who had come to autopsy. Twenty-four of these patients had suffered from schizophrenia. He noted that the areas of lipoid degeneration were never found when the frozen section material was used. They could be discerned, however, when alcohol fixation was employed. Though they occurred in other types of mental disorder such as general paresis, arteriosclerosis, epilepsy and senile psychoses they were found more frequently in the schizophrenic group.

Freeman also reports that the intracellular fat appeared in the schizophrenic group earlier than in the other psychotic reactions. Though he confirmed the statement of Buscaino to the effect that the increase in intracellular fat in the thalamic and pallidal regions was probably greater in the schizophrenic patients than in those suffering from other types of disorder, he did not find that the area of maximum deficit could be correlated with the various subtypes of schizophrenia. Freeman further reports the presence of calcareous changes in the blood vessels of the globus pallidus which occurred at a very early age in his schizophrenic patients. It is of interest to note that one of the few aspects in which Dunlap (1925) found his normal control and his schizophrenic material to differ was the presence in the latter of slightly more lipoid in the brain tissue.

Swelling of the oligodendroglial cells has been reported in brain biopsy specimens taken from the left and right parietal-occipital regions in patients suffering from schizophrenia and manic depressive reactions (Elvidge and Reed, 1938). This change was also present in three out of four epileptic patients.

General Paresis. The changes in the structure of the central nervous system have been known for long. Unfortunately they are so diffuse that it has not been possible to derive from study of this condition much information concerning the relationship between brain structure and behavior. The most striking change in brain structure is the occurrence of marked proliferation of the capillaries together with a considerable infiltration by plasma cells. There is a degeneration of ganglion cells and of axis cylinders which Ammossow and Masjillo (1932) consider to be secondary to impairment of the circulation due to invasion of the walls of the local blood vessels. Atrophy of the brain is present and is most marked in the parietal region. Compensatory increase in the cerebrospinal fluid may occur. Wertham (1932) states that the four cardinal histological findings in general paresis are (1) infiltration by plasma cells; (2) increase in the number of Hortega cells; (3) accumulation of iron in the intra-adventitial spaces of blood vessels as well as in the Hortega cells; (4) the presence of spirochetes in the cerebral tissues. Wertham has suggested that, in view of the fact that these first three cardinal signs can be found elsewhere, namely, in a disease of chickens which he reports, we can no longer consider the lesions of general paresis as strictly specific.

The presence of iron in unusual amount in the cerebral tissues of patients suffering from general paresis was first reported by Bonfiglio (1912). It is found in largest amounts in the cortex and corpus striatum. Very little is present in the substantia nigra, the pallidum or the optic thalamus (Merritt, Moore and Solomon, 1933). These authors state that the origin of the iron is not clear. It certainly does not seem to be derived from hemorrhages or from diapedesis of red cells. Hadidian and Hoagland (1939) suggest that it may represent a precipitation of part of the catalytic iron normally present in cerebral tissues. This view derives support from the statement that the total amount of cerebral iron in general paresis does not deviate from normal (Freeman, 1930). Hadidian and Hoagland suggest that this conversion of catalytic iron may account for the fact that study of the temperature characteristics of alpha brain wave frequencies shows that there is a slowing of an iron catalysed link in cortical respiration. The presence of precipitated iron is such a constant phenomenon in general paresis that it has been used as a means of diagnosis in the living subject. Brain puncture is carried out (Foerster, 1912) and a specimen treated by means of the Turnbull blue method whereupon the characteristic reaction appears.

Encephalographic studies in patients suffering from general paresis have not resulted in any considerable advances. Ginsberg (1930) describes the varying degrees of atrophy which may be found. He states that it is usually most marked in the case of the frontal lobe and that atrophy of the temporal lobe occurs only in those patients in whom hallucinatory activity is well developed. He also notes that the enlargement of the ventricles is often asymmetrical and that the side on which maximum enlargement is present is often associated with contralateral increase in tendon reflexes. Ebaugh *et al.* (1931) carried out similar investigations. They were not able to demonstrate any reliable correlation between the degree of atrophy shown by this method and the prognosis with respect to treatment.

Senility. The structural changes which may occur in senility have been well summarized by Critchley (1939). The outstanding feature is a general atrophy which is usually most apparent in the frontal and occipital poles. Atrophy of the white matter is usually greater than in the case of the gray matter. Microscopic examination shows that there is considerable loss of ganglion cells, particularly in the third layer of the cortex. This loss is most apparent in the frontal region. Pigmentary changes are common.

Critchley also describes the presence of thickening of the intracellular fibrils with later disappearance of the cell wall. These coiled fibrils are known as Alzheimer fibrillary bodies. Another typical finding consists in a thickening of the axons of the Purkinje bodies to produce the so-called "torpedoes" — spindle-shaped enlargement of the axons.

Senile plaques are frequently found, particularly in the deeper layers of the cortex of the occipital, frontal and temporal regions. These will be discussed in greater detail. The changes in the cerebellum are somewhat similar, "torpedoes" being frequently present and senile plaques absent.

The presence of these bodies in senile brains and in the brains of persons suffering from Alzheimer's disease has long been known. At one time an effort was made to differentiate between the brains of senile individuals, who showed no gross behavioral disorder, and the brains of persons suffering from senile psychoses upon the basis of the number and distribution of senile plaques. This has proved to be an undependable criterion. As yet it is impossible to state from simple investigation of the brain structure whether or not the changes were likely to have been accompanied by severe disturbance of behavior.

The origin of senile plaques has been the subject of considerable enquiry. Bouman (1934) considers that the Alzheimer fibrillary bundle, the senile plaque and the torpedo are capable of being explained by means of a single hypothesis. He considers that in the senile brain a tendency towards "hyperdifferentiation" is apparent. If this process occurs in a ganglion cell there results an Alzheimer fibrillary bundle; if it occurs in the course of a neuron a torpedo may be formed, and if it occurs in the ground reticulum a senile plaque is produced. Hiroisi and Lee (1936) advance the point of view that senile plaques result from a specific mucinoid degeneration of oliogodendroglia cells.

The question of the relationship of the structural changes in the central nervous system to behavior, which was touched upon previously, has received further attention from Rothschild (1937). He states that the changes found in persons suffering from senile psychoses may readily be duplicated in senile persons whose behavior is quite within normal limits. The suggestion is put forward that the ability of the individual to make use of his remaining cerebral assets is a major factor in determining whether or not his behavior becomes abnormal.

From our own experience and investigations (Cameron *et al.*, 1940) it appears highly unlikely that a satisfactory correlation between senile changes in the central nervous system and behavior can be worked out without reference to such variables as the general physiological efficiency of the organism, the customary reaction tendencies at the behavioral level and the sociological setting. The purely pathological approach is, in the light of our present orientation with reference to behavior, entirely inadequate to afford more than a partial explanation.

The situation with regard to the so-called arteriosclerotic psychoses is similarly unsatisfactory. It is practically impossible to differentiate senile from arteriosclerotic psychoses on a clinical basis, and the degree of vascular involvement bears only the most indirect relationship to the degree of behavior change. The most adequate description of the changes which may be found in the arteriosclerotic psychoses is that which White (1919) derived from Alzheimer. Four different forms of lesions may be present, namely: (1) arteriosclerotic brain atrophy which is accompanied by atrophy of the ganglion cells and proliferation of glia; (2) subcortical encephalitis which is characterised by atrophy of the white substance due to disease of the long medullary vessels; (3) perivascular gliosis due to obliteration of the smaller blood vessels with atrophy of the nerve cells supplied by them; (4) senile cortical devastation which consists in degeneration of the smaller vessels of the cortex with break-up of the nervous elements.

Mental Deficiency. It is well known that the primary cause of mental deficiency is not always to be sought in the central nervous system (cf. effects of thyroid lack upon the function of learning). In other instances mental deficiency is clearly associated with gross abnormalities or injuries such as tuberose sclerosis, internal hydrocephalus or cerebral diplegia as well as with an uncomplicated cerebral deficiency. It is generally agreed that, apart from certain special cases such as internal hydrocephalus, the brain of the mentally defective individual is below normal in weight and size. Moreover, asymmetries are frequently reported. Ashby and Stewart (1933, 1934) have pointed out that, if the mentally defective individual shows a general reduction in size and weight, the measuring and weighing of particular parts such as the brain in the hope of thus revealing deviations from the normal weight and size can have no significant bearing upon the question of the cause of the deficiency, unless the weights and sizes of those particular parts can be shown to be out of proportion to the weight and size of the organism in general.

Ashby and Stewart (1935) measured the width of the convolutions in a group of 54 mentally defective individuals and 8 normal individuals. They found very little difference in the mean width of the convolutions in both groups but the widths in the case of the mentally defective group tended to be rather more variable. Berry (1925), from detailed measurement of the brains of 31 defective individuals, concluded that they were 20 per cent smaller on the average than the brains of normal individuals and that they showed considerable deviation from normal with respect to the relationship of the size of their constituent parts. He found this to be so with respect to the angle of the rolandic fissure, the length of the associated cortical areas and the cerebral height. In particular there was a definite disproportion between the main prerolandic and postrolandic cortical areas and this was specially noticeable with respect to the parietal area.

Meyer and Cook (1937), who examined the brains of 22 patients who had suffered from various types of mental deficiency, found a high incidence of diffuse gliosis in the white matter. It was suggested that a vascular factor or some other form of defective oxygenation might be the cause.

The cellular richness of the cortex has frequently been put forward as the basis of functional superiority. This viewpoint was investigated by Norman (1938). He counted the cells in the second and third layers of the supragranular cortex in three areas: (1) an area immediately posterior to the point where the parieto-occipital fissure transects the convexity of the hemisphere; (2) the frontal pole; (3) the anterior and dorsal parts of the supramarginal gyrus. This material was selected from 30 normal control brains and the brains of 30 patients who had suffered from mental deficiency. No brains were included in the latter group if gross abnormalities, such as internal hydrocephalus, microgyria, tuberose sclerosis, lobar sclerosis or porencephaly were present. He found that there was no significant difference between the two groups in the mean depth of cortex. Cellular poverty was not outstanding in the defective group, though local areas poor in cells were more common in this group. The cells were more irregularly placed in the mentally defective brains and the average cell counts of sections were more variable. Norman notes that those areas of the neopallium which are most recently acquired show the greatest incidence of defects.

The chemical constitution of the brains of 62 mentally defective individuals has been contrasted with that of 9 normal adults (Ashby and Glenn, 1935). They found that there was a positive correlation between mental age and water content — the normal brains tended to be drier, the myelin content was the same in both groups and there was no change in the lipoids. Protein phosphorus was present in greater amount in the brains of the mentally defective group.

Autonomic Nervous System. Little is known concerning the relationship between changes in the structure of the autonomic nervous system and behavior. Reference has already been made in the section dealing with this system to the fact that removal of considerable portions of the system in animals did not greatly affect their behavior. Reference has also been made to the fact that the reactivity of the autonomic nervous system may be abnormal in the schizophrenic reaction. Evidence of actual structural change is, however, still lacking.

Some enquiry has been directed to the hypothalamus, in the lower parts of which integration of many of the motor activities of the autonomic nervous system is carried out. Morgan (1930, 1939, 1940) has reported post-mortem studies upon the hypothalamic area of patients who had suffered from epilepsy and mental deficiency, as well as a group who were described simply as having been psychotic. He found chromatolysis and cell loss in all groups. These findings were more marked in the nucleus tubero-mamillaris in the epileptic group, while it was most prominent in the nucleus paraventricularis and nucleus supraopticus in the mentally defective group. These findings await substantiation as well as extension in the direction of simultaneous comparative studies in other regions of the brain.

Endocrine System. The correlation between variations in the functioning of the components of this system and behavior have already been considered in more detail. (*See* chapter on Endocrine Function.) Certain forms of structural deviations will be considered in this section since as yet they have been reported only after post-mortem examination.

Among these deviations are those changes reported by Mott (1920[a, b], 1922) as being found post-mortem in the testicles of patients who had suffered from schizophrenia. These changes consisted in regressive atrophy and failure of spermatogenesis. He described three stages: the first, in which spermatogenesis was less active than usual and the spermatozoa poorly formed; a second, in which spermatogenesis was almost arrested and there was an excess of interstitial tissue, and a third stage in which there was almost complete disappearance of the spermatogenic cells, the only cells remaining being the cells of Sertoli.

Mott also reported the work of Foerster upon the ovary in the schizophrenic. He stated that there was a regressive atrophy and a failure of the primordial follicles to develop. The ovaries were frequently found to be small, shriveled and densely fibrous organs which showed no Graafian follicles. In Mott's opinion there was a correspondence between the duration of the symptoms and the severity of the changes in the testicles.

In answer to the criticism that these changes in the testicle and ovary might be more properly associated with the presence of chronic disease, such as tuberculosis, which is common among schizophrenic patients, Mott stated that it is well known that the schizophrenic woman is not unfertile. He pointed out further that when schizophrenic women had died of acute intercurrent conditions the changes in the ovary which were described above were found to be present. Mott regarded these changes as evidence of an inherited vital deficiency which made itself manifest particularly at the period when an extra strain is thrown on the organism by the establishment of reproductive life.

While these findings have been considerably criticized, Lewis (1923) has offered some degree of confirmation. He states that in 10 out of 18 pairs of testicles from schizophrenic patients complete absence of spermatogenesis was noted while there were degrees of regressive atrophy in the remaining 8. He did not, however, find any degree of correlation between the duration of the disorder and the amount of change in the testicle. He suggested that the cyanosis of the extremities may, to some extent, depend upon the degree of insufficiency of the gonads.

In this investigation the adrenal glands were found to show almost as extensive a series of lesions as did the gonads. The cortex, which is known to have important interactions with the sex glands, was thinned out and pale in color. In only 5 out of 22 patients were the glands normal in size; in 2 they were above average. Microscopically the cortex showed a tendency to exhibit regressive changes with overgrowth of fibrous tissue.

The thyroid gland in this group of schizophrenic patients was also found to show changes. It tended to be smaller than usual in size, and there was a generalized enderosis and loss of colloid. The changes in the pancreas and pituitary were not particularly distinctive.

Some further light with respect to these findings in the case of gonads and the thyroid has been thrown by an exhaustive study of the relationship of the weights of the various endocrine glands to four major psychotic reactions — epileptoids, cycloids, paranoids, schizoids (Pearl, Gooch and Freeman, 1935). It was shown that it was not possible to distinguish between the groups on the simple basis of the weights of the endocrine glands examined — gonads, thyroid, thymus, parathyroid, adrenals, pituitary, pineal. It was, however, possible to state that each reaction type differed from the normal control group in that in the case of the first there was a definite deficiency in thyroid tissue. In the case of the psychotic men there was a slight deficiency of gonad tissue; in the case of the women the deficiency in ovarian tissue was more definite. There was a marked excess of parathyroid and thymic tissue in the psychotic group, and a lesser excess of adrenal tissue. There was little if any excess of pineal or pituitary gland tissue in this group. The authors point out that their findings offer no support to claims that any pattern of endocrine deficiency can be associated with a definite type of abnormal behavior reaction. It must, of course, be borne in mind that the data under consideration are derived solely from the weights of the glands examined and can therefore offer only indirect information as to their functional efficiency.

Cardiovascular System. While the greater part of the work carried out upon the cardiovascular system in relation to behavior has been done in the living subject some information has been derived from post-mortem examination. Considering first the structure of the system as a whole one finds that widespread deviations from normal are reported to occur in schizophrenia. Lewis (1923, 1936) found that there was a marked tendency toward aplasia of the whole system. The heart was small, and appeared to have been arrested in its development, having passed little beyond what is usually found at puberty. Gross lesions are unusual, and it is noted that where valvular lesions occur the heart has apparently little capacity to compensate nor is the tendency present, which that organ usually shows, to increase slightly in size with age. The aorta is small and often will not admit the first finger. Its intima frequently resembles that of early life. The main branches of the aorta were found to share in this aplasia. The blood vessels of the brain were also found to show this change and the capillaries of many of the viscera were found to be small when examined microscopically.

Lewis also noted that there was very frequently associated with this aplasia of the circulatory system, a considerable enlargement of the lymphatic system. This he considered might be associated with the proneness of the schizophrenic patient to tuberculosis. Finally, he recorded the observation that both the changes in the endocrine glands, which were described above and those reported as present in the cardiovascular system, are not characteristic of the paranoid group of schizophrenics, and for this reason he raised the question whether the paranoid group is to be considered as closely related to the rest of the schizophrenic complex or as having a more independent existence.

The size and position of the heart have been investigated during life in a series of schizophrenic patients (Reed, 1932).

No evidence that "dropped heart" was common in this condition was forthcoming, and save for the catatonic group there was no evidence that the heart was smaller on X-ray examination than was that of the normal controls. In this connection reference may be made to the work of Farrell and Vassaf (1940) who showed in a small group of schizophrenic patients that the heart grew larger as insulin treatment progressed and that there was some indication that it increased most definitely in those patients in whom a clinical improvement was taking place.

Some further information in this field has been gained through the development of capillary microscopy. Schrijver-Hertzberger (1932) studied the capillaries in the nail fold in an extensive series of patients which included schizophrenic, manic-depressive, epileptic, feeble-minded and senile individuals. He found that pathological forms of capillaries, particularly those showing ramifications and cross communications, were more common in the psychotic group than in the normal controls. Dilatation of the lumen was more frequently found in those abnormal capillaries. In the mentally defective individuals, particularly in the younger group, a characteristic abnormality was found, this consisting in a widening of the under side of the capillary loop. Agreement has not yet been reached in this field (Suckow, 1932). It would seem quite probable that in the case of mentally defective individuals and in certain psychotic individuals in whose illness heredity seems to play a considerable part, abnormalities of the form of the capillaries might be found. In such situations the reaction is, in a very real sense, total; and evidences of deviation from normal are found at all functional levels. We feel that it is most desirable to stress the simple fact that when abnormalities can be demonstrated it is still necessary to show how far they are important to the activity of the whole organism.

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CHAPTER XXIII

HEREDITY

In the opening chapter the problem of locating the various functions of the organism in a significant scale was discussed. The possibility of setting up such a scale upon the basis of the relative speed of adaptation shown by the various functions was put forward.

It is reasonable that the extremely slow changing functions which are considered under the term heredity should be placed at the opposite end of the scale from the rapidly adaptive functions of learning and remembering. Indeed, in view of the fact that the postulate of the inheritance of acquired characteristics has not been substantiated, some theoretic difficulty arises in including these slow changing functions in our scale.

This can, however, be surmounted if we place our emphasis upon the fact that there is some evidence that inherited functions do undergo slow modification during the life of the individual. Further, there is evidence that, while this modification is probably not directly transmitted from one individual to his descendant, constant modification of inherited functions is carried out within the species by means of selection and mutation.

Turning from these theoretical considerations to the data which have already been accumulated upon the problem of inheritance in the field of human behavior, one must rapidly gain the impression that little of it is fated to withstand the closer scrutiny of more exact procedure.

A great deal of it rests upon the simple process of counting heads and much of it, witness the Kallikak study, consists in counting heads long since dust and regarding which we have little more than hearsay evidence. Again much of it has been collected without regard to controls, and even when controls have been used, there has been little realization of the necessity of planning with care the composition of the samples under consideration.

When all these safeguards are erected it is still possible to make only rather general statements as to the effect which heredity has upon the incidence of mental disorder.

Such work is already being carried out and although it is true that as yet it has not sufficiently advanced to allow of many practical applications in the psychiatric field, it is also true that a knowledge of what fundamentals have been uncovered in the laboratory will both guard us against a number of pitfalls, and also will save us from sweeping statements which cannot be objectively verified.

Much of modern thinking in genetics draws its inspiration from certain fundamentals of embryology and an understanding of the following facts drawn from this science is necessary. During maturation the germ cells undergo two divisions which are of considerable importance. Prior to the first division the chromosomes group themselves into pairs, a member of each pair passes to the opposite poles of the cell which subsequently divides, thus leaving the daughter cells with half the number of chromosomes. Without this procedure the cell resulting from the union of sperm and ovum would have twice the number of chromosomes peculiar to the species involved. The daughter cells then undergo a second division; during this the chromosomes divide longitudinally thus preserving their number at half that found in the rest of the cells of the organism. While this is the procedure in the sperm cells, in the mother cells of the ova the procedure is slightly different. The first division results in the formation of a very small body known as the polar body, and of a cell which again divides to give rise to a second polar body and the ovum. The first polar body usually divides again, thus giving three polar bodies and an ovum (Morgan 1929).

The longitudinal splitting of the chromosomes during the second division of the maturing cells assumes considerable importance in the light of our recent concepts of the genes. Interest has been focused for a considerable time upon the chromosomes as being the element of the germ cell principally concerned with the transmission of inherited characteristics. The number of inheritable characteristics or unit characters is now known to be very considerable, far more than could be accounted for by arrangements of the chromosomes if the latter were to be taken as having unit functions. Accordingly, it has been suggested that the chromosome is not a homogenous body but is composed of a large number of smaller units named genes. It has to be borne in mind that these have not yet been demonstrated microscopically but in spite of this, their supposition has permitted considerable further advances being made. Thus it will be seen that the longitudinal splitting of the chromosomes is of considerable importance in insuring that there is an equal distribution of genes among the daughter cells (Metz, 1923). These assumptions in regard to the activity of the genes and their rôle in the mechanics of heredity fit in well with Mendel's concepts.

Mendel's concepts have come to acquire a dominant position in work upon inheritance. It can now be fairly said that when a unit character is clearly recognized and its characteristics as dominant or recessive are known, accurate predictions can be made as to its appearance in successive generations when the matings are controlled.

It is to be noted, however, that due to a tendency which characters show to stay together in inheritance, they fall into groups which are not invariably preserved; where they separate, the separation is to be ascribed to a separation of the genes. This phenomenon is known as "crossing over."

This crossing over is considered to occur at the conjugation during the maturation of the germ cells. It consists in an interchange of parts between two homologous chromosomes. It is to be borne in mind that at this stage the division of the chromosomes takes place in a longitudinal manner so that the crossing over will occur among genes which will have a definite spatial relationship (Metz, 1923; Morgan, 1929).

The tendency to cross over, as shown by different combinations of genes, varies considerably and from this the serial order of the genes and their distance apart have been calculated. These results have permitted the plotting of maps which show the sequences and distances of the various genes. On the basis of those maps predictions of very considerable accuracy may be made.

From the foregoing, the very great significance of the experimental methods of Mendel and the later studies of chromosomes and genes for an understanding of heredity will be perceived. As yet our studies have not sufficiently clarified the nature of many of the more important of the unit characters in man, and though we have reached a recognition of the importance of the gene and can make reliable forecasts regarding its behavior, we are not yet in a position to influence its behavior. Work, however, in this direction shows great promise, and we venture to suggest that its pursuit holds much more for us than the business of "head counting."

Turning to the question of inheritance in the human subject, there is little doubt as to many of the characteristics that are inherited. Among those that are best authenticated are eye color and certain diseases of the nervous system, such as Huntington's chorea. The situation in regard to inheritance of the higher functions is not so clear, as will be demonstrated.

Before proceeding to the consideration of that point our attention must be directed to the question of the possibility of the inheritance of acquired characteristics. The importance of a decision in the matter of whether or not the skills which the individual has acquired during his lifetime can be transmitted to his offspring is the obvious cause for the considerable amount of work which has been produced upon this subject. If skills and habits and even learning could be transmitted to the next generation, we should clearly be in possession of a weapon of the greatest eugenic value. The work upon this topic is well discussed by Morgan who points out that, while the original proponent of this point of view, Lamarck, based his claims upon evidence which would in no way satisfy present-day criticism, later workers have set up much more searching experiments. Among them is Griffiths (1922) who rotated rats for long periods in pens with subsequent production of nystagmus and a twist of the head. Disequilibration was reported in the descendants of these rats. Later, however, disequilibration has been found to occur in rats without previous rotations. He comments upon the work of Guyor and Smith (1918, 1920) in injuring the lens in the rabbit by needling. In some of the descendants of these rabbits eye defects were found. These defects were, however, sporadic and not beyond the range of the normal occurrence of such defects. Subsequent work has failed to confirm these findings. Morgan also comments upon the claims of McDougall to have found that skill in maze running was transmitted, and the claims of Pavlov that conditioned reflexes in mice, consisting in a response to a bell as a call to food, were also transmitted. Neither of these claims has been substantiated. The whole question of acquired characteristics must at present be adjudged non-proven.

Methods. Means of various degrees of refinement and of applicability have been worked out to deal with the problem of heredity in the human organism. Whatever the means employed, work in this field suffers from the serious defect that the life span of the object of study is the same as that of the observer. For this reason much of the material which any given worker has to deal with must be obtained second-hand. A further difficulty consists in the fact that experiments cannot be set up to order, as has been so readily and successfully done in the field of plant and animal genetics.

The early methods consisted in variations of the field survey. This has been carried out by selecting the records of an individual showing certain behavior characteristics which it is desired to study and following the records of his descendants. This method was used in the case of the study by Goddard (1925) of the Kallikak family. It is now generally agreed that the documentation of this study was inadequate. More recent investigations which have utilized this procedure have sought their material in areas where detailed records of vital statistics have been kept during the period under consideration.

A second allied method consists in the collection of a group of persons showing the behavioral reaction under study and contemporary investigation both of the group and of their descendants. Such a study is well exemplified by the investigations of Canavan and Clark (1935) upon the children of a group of schizophrenic patients.

More recently the twin method has been introduced as an entirely different means of approach. Twins are classified as similar and dissimilar. By dissimilar twins one designates those twins whose appearance and behavior do not show a closer identity than that found between other non-twin siblings in the same family. By similar twins we mean twins who show a considerably higher degree of similarity than exists between other siblings in the same family. It is a matter of common experience that, at all events in the younger years before chance accidents and diverging environment have imposed differences, it may be all but impossible to distinguish between such twins without reference to special identification marks. To account for these differences between the two types of twins, it is assumed that the dissimilar twins arise from the simultaneous fertilization of two ova, while the similar twins arise from an early division of the blastoderm. Evidence in favor of this assumption is largely circumstantial and is based upon the fact that, while dissimilar twins may be of the same or opposite sexes, similar twins are always of the same sex; moreover, in the case of similar twins there is found to be only one placenta and one chorionic membrane. Clearly if this assumption in regard to the genesis of twins is correct very important light can be expected to be thrown upon the effects of heredity and environment. It will be understood that in the case of the uniovular twins each twin will have the inheritable characteristics conveyed by the same set of chromosomes, while in the dissimilar twins there are two sets of germ cells involved.

In considering the results obtained by this method of study it is important to bear in mind certain valid criticisms. The first is that the theory of origin of similar and dissimilar twins has never been substantiated. The matter of diagnosis on the basis of single and double membranes is less relied upon since it has been shown that there are dichorial similar twins and also mirror twins (Slater, 1938). More emphasis has now been placed upon the presence of multiple points of resemblance. This latter procedure, of course, to a large extent begs the whole question under consideration. A second line of criticism concerns the method whereby the series of twins under investigation has been collected. The earlier studies, due to the limited number of twin records available, made considerable use of cases collected from the literature. This procedure contained several serious errors and resulted in the apparent contribution of heredity being assessed at too high a value (Luxenburgher, 1930). Twin studies are now set up upon the basis of a survey of all the descendants of a given group irrespective of whether those descendants have attracted official attention by commitment to hospital or not.

Lastly, the findings within the field of genetics, however obtained, require rather more cautious consideration than has been given them by certain of those responsible, for it would seem that many workers regard the possible inheritance of a tendency to schizophrenia in much the same light as they do the inheritance of eye color or polydactylism. In actuality, while the latter characteristics, when inherited, remain in fixed form throughout life, there is no reason to believe that inheritance at the higher functional levels does not show the same greater degree of modifiability which has been noted (*see* Chapter I) as characteristic of the higher functional levels generally. This point of view receives support from such studies as those of Newman, Freeman and Holzinger (1937) where it was shown that the intelligence scores of identical twins separated shortly after birth were clearly affected by the type of environment in which they were brought up.

Higher Level Functions. The range of higher level functions which have been investigated has been limited by the lack of reliable methods of estimating these functions. The genetic technique, which has been almost exclusively applied, is the twin method. It has been possible to show repeatedly (Merriman, 1924; Stocks, 1929) that identical twins are more closely related with respect to their intelligence scores than are any other types of sibling. Gesell (1930) followed over a period of years the development of a pair of gifted and a pair of retarded identical twins. He found that there was a very considerable resemblance not only in the intelligence scores but also in the times at which they attained the various developmental levels. Carter (1935) has investigated the emotional traits of a series obtained from the California high schools and composed of 40 identical twins, 44 like sexed fraternal twins and 34 unlike sexed pairs, as well as 15 pairs of mature identical twins. He made use of the Bernreuter Personality Inventory. He found that twins are, as a whole, more stable and more extroverted than children in general. He also found that identical twins were more similar than fraternal twins in all personality traits with the possible exception of introversion. In discussing these findings, as well as his earlier studies upon behavioral traits in twins, he acknowledges that the method does not permit adequate differentiation of the effects of heredity from those of environment. He believes, however, that even in the development of social attitudes heredity plays a larger part than has been considered heretofore to be the case.

Yule (1935) has investigated the similarity of twins with respect to perseveration. She made use of Stephenson's "p" tests for this purpose. (*See* chapter on Personality Functions for criticism of this procedure.) She found that monozygotic twins were more alike than dizygotic twins with respect to the amount of perseveration which was shown. In considering these results one must again refer to the work of Newman, Freeman and Holzinger (1937) who have shown that when identical twins are reared apart considerable divergences in their intelligence scores appear and that these divergences increase with time. The part which the environment plays is probably particularly important with respect to the development of personality functions.

Mental Deficiency. The earlier work in this field was somewhat handicapped by the original belief that mental deficiency was a unit character and that it was probably recessive in type. More recent investigations have shown that both these contentions are unsound. Sjögren (1931) has been able to demonstrate that amaurotic family idiocy meets all the qualifications of a recessive type of heredity. These qualifications are that practically all the individuals who exhibit the character should have parents who do not manifest the character in themselves. The siblings show the character in about a quarter of the cases and the parents will frequently be found to be consanguineous (Penrose, 1938). Studies by Penrose (1935) and Jervis (1939) have served to show that phenylpyruvic oligophrenia is due to a single autosomal recessive gene. The latter worker points out that certain practical considerations arise from this fact. He urges that the parents of children who show this condition should be discouraged from further pregnancies as should the brothers and sisters, uncles and aunts of the affected individuals. He indicates the particular desirability of preventing marriages between members of an affected family stock.

Certain types of mental deficiency appear to be due to a single dominant gene. The characteristics of this condition are that one parent shows the character while the other is normal, and the character is manifest in almost half the siblings (Penrose, 1938). These qualifications are met by such conditions as Huntington's chorea, tuberose sclerosis and multiple neurofibromatosis. Using the twin method, Rosanoff and Handy (1934) have reported that this condition does not appear to be hereditary in the strict sense of the word. They consider that the condition arises from damage done to the ovum, and suggest that attention should be directed to the scars located at the sites of old ovulation as the possible source of the damage.

From the above statements it will be readily seen that the older view of mental deficiency as a unit character has been rendered quite untenable. This is given further emphasis by the fact that much of what is generically termed mental deficiency is not hereditary in the strict sense. Rosanoff et al, (1937), on the basis of a study of 366 pairs of twins suffering from mental deficiency, report that hardly more than half of such cases are due to definite hereditary factors. The remainder are due to germinal, fetal, or birth damage.

Schizophrenia. The studies which have been made upon the part played by heredity in the production of the schizophrenic reaction carry only limited conviction. Foremost among the difficulties which lie in the way of obtaining a clear-cut answer to genetic studies in this field is the difficulty of establishing a satisfactory diagnosis. This is rendered still more confusing by reason of the fact that it is generally conceded that schizophrenia is a generic designation for a group of disorders rather than a functional entity.

Many of the workers in this field have apparently given little weight to the possibility that the schizophrenic reaction may be, at least in part, occasioned in individuals by the fact that they grew up in families in which a parent or a sibling suffered from this condition. One of the most painstaking studies in this field is that of Kallmann (1938) and Kallmann and Rypins (1938) who investigated the families of 1,087 schizophrenic patients. They concluded that the inheritance of schizophrenia is specific and that the probable incidence of schizophrenia among the offspring of schizophrenics is nineteen times greater than in the general population. In the case of the children of two schizophrenic patients the probability is 68.1 per cent while if one of the parents is schizophrenic and the other normal the expectancy is 14.8 to 23.9 per cent. On the basis of a much smaller patient material Schulz (1940) found that the expectancy was 41 per cent where both parents were schizophrenic and 15 per cent where one of the parents was normal. In view of the fact that the methods whereby these studies were carried out contained no means to eliminate the effects of environment in the production of schizophrenia in the families of these patients, the data must be regarded with considerable reserve. Of more unequivocal value is the fact that in Kallman's study it was found that 70 per cent of the children of the schizophrenic patients were born before the first commitment to hospital. This has a bearing of considerable practical importance upon the genetic measures which may be taken to deal with the condition. Clearly sterilization of patients who have already broken down is likely to be of little avail. We would suggest that claims that strictly hereditary factors play a dominant part in the production of schizophrenia must meet the following facts: (1) the condition may appear at any time from the age of 5 up to the sixth decade, suggesting that the business of living has an influence in determining its appearance; (2) it does not appear in all offspring even when both parents are affected; (3) the reaction may show spontaneous remission; (4) it may show remission under treatment.

Manic-Depressive Reaction. The genetic work which has been carried out in this field is quite limited. Rüdin (1923) investigated the siblings of 566 patients suffering from manic-depressive reactions and found that 7.4 per cent of their siblings were similarly affected. Humm (1932) has investigated a large series of patients showing various types of behavior disorder. On applying the twin method he found that the incidence of breakdown was considerably higher in the monozygotic twins where one was already affected than in any other groupings of siblings. From this he concluded that heredity played a part in the production of the disorders under question. No data were worked out concerning the hereditary factor in the manic-depressive reaction by itself. Pollock, Malzberg and Fuller (1939) and Pollock and Malzberg (1940) have investigated the 2,377 relatives of a group of 155 patients suffering from manic-depressive psychoses. They found that the expectation of manic-depressive disorder in these relatives was considerably less than would be the case if the transmission of this condition had been on the basis of simple mendelian inheritance. They feel justified in concluding, however, that there is some evidence in favor of a familial predisposition.

Epilepsy. The situation here is somewhat similar to what obtains in the case of schizophrenia. Great difficulty is experienced in determining what constitutes epilepsy. There is, of course, little question that epileptiform attacks which accompany other disorders, especially those located in the central nervous system, are not to be considered in the same category as those attacks which appear without accompanying disorder. It seems probable that within this second group there are many subdivisions. Paskind and Brown (1937) have shown that those epileptic patients who do not show deterioration show a lower incidence of epilepsy in their parents than do those who do show deterioration and require later hospitalization. It is an interesting commentary upon the question of the unitary nature of epilepsy that these workers found that other abnormalities such as alcoholism, apoplexy, psychotic reactions and senile dementia were more common among the relatives of deteriorated institutionalized epileptics than among those who could adapt to everyday life.

In general field studies have yielded most varied and conflicting data. Muskens (1928) states that he found that hereditary factors were present in 28 per cent of his epileptic patients. Stein (1933) studied the records of 1,000 institutionalized epileptic patients and a group of 1,115 nonepileptic normal controls. He found no evidence to suggest that there was any specific inheritance of epilepsy but did find that the incidence of neuropsychiatric conditions as a whole were more common among the relatives of the epileptic group.

A further means of study has been developed upon the basis of the brain wave records of the relatives of epileptic patients. Lennox, Gibbs and Gibbs (1939) and Löwenbach (1939) have described in the records of the nonepileptic relatives of epileptic patients the occurrence of slow waves appearing in bursts. In certain instances these irregularities took the form which is frequently associated with petit mal epilepsy, namely, slow large amplitude waves and spikes. (*See* chapter on Electrical Phenomena.) The incidence of these abnormalities could be increased upon having the subject hyperventilate. The question naturally arises as to whether this indicates the presence of a latent epilepsy of which these normal individuals are the carriers or whether it indicates rather a general instability of the central nervous system. There is some evidence to suggest that the latter is the more probable explanation, but the field requires considerable further exploration before a clear-cut answer can be given.

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